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THE

ASTRONOMICAL JOURNAL

EDITED BY

BENJ. APTHORP GOULD

VOLUME XV
FEBRUARY TO DECEMBER, 1895
NUMBERS 337-360.

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WITH ONE PLATE

BOSTON
1895

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THE

ASTRONOMICAL JOURNAL.

No. 337.

VOL. XV. BOSTON, 1895 FEBRUARY 15. NO. 1

MICROMETER-OBSERVATIONS OF THE SATELLITES OF *MARS*,

By W. W. CAMPBELL.

The following observations of the satellites of *Mars* were obtained with the filar micrometer of the 36-inch equatorial. The angles were observed by passing a wire through the satellite and the estimated center of gravity of the planet's bright disc. Either two, three or four — for the most part three — individual measures have been combined to form each result as printed. Each observed distance, as given, is the mean of two measures. The distances were measured either from the nearer limb (or terminator), or from the farther limb (or terminator), or from the two in succession. In the column "Observed distance" all the results opposite or following the mark (*) were obtained by measuring from the nearest limb (or terminator); all the results opposite or following the mark (†) were obtained by measuring from the farthest limb (or terminator); and all the results opposite or following the mark (‡) were obtained by measuring from both limb and terminator. I regard the last method as by far the most satisfactory, and all the observations subsequent to Oct. 25^d 6^h 42^m were made in that manner.

The corrections for refraction, Δp and Δs, were computed by BESSEL's method as given in CHAUVENET's *Spher. and Pract. Astron.*, Vol. II. equations (349) [fifth edition].

The corrections to the observed angles for phase, $\Delta p'$, were obtained in this manner: let E be the phase-angle of *Mars*, Q the position-angle of the greatest defect of illumination, g the distance from the center of gravity of the bright disc to the middle of the line joining the two cusps, r the radius of the circular disc, π the ratio 3.1416, and p and s the position-angle and distance of the satellite; then

$$g = \frac{8}{3\pi} r \sin^2 \frac{E}{2}$$

and

$$\Delta p' = \frac{57.3 g}{s} \sin (p - Q)$$

The corrections to the observed distances for phase were computed from the equation

$$\Delta s' = r - \frac{r(r-q)}{\sqrt{r^2 \cos^2 (p-Q) + (r-q)^2 \sin^2 (p-Q)}}$$

in which q is the defect of illumination in the direction Q. Those distances which were measured from the terminator require the full correction $\Delta s'$ for phase. Those made with reference to the limb require no correction for phase. Those obtained by measuring from both terminator and limb in succession require the correction $\frac{1}{2} \Delta s'$. The required values of the correction are contained in the column $\Delta s'$.

The measures made from both terminator and limb require no correction for semi-diameter. Those made with reference to either one or the other have been corrected by applying HARTWIG's value of the semi-diameter increased by 0″.26. The diameters of *Mars* measured on eleven nights were greater than HARTWIG's by the following amounts:

″ 0.54	″ 0.49	″ 0.56
.61	.42	.63
.45	.54	0.60
0.40	0.56	

Mean = 0.53

Therefore, I increased HARTWIG's value of the semi-diameter by 0″.26.

As far as possible I have used MARTH's notation, and both in the observations and reductions I was continually indebted to his ephemeris.

E. B. CAMPBELL rendered efficient assistance by noting the time and keeping the records during a large part of the observations.

POSITION-ANGLES OF *Phobos*.

Pac. Standard Time 1894	Observed angle	Δp	$\Delta p'$	Corrected p	No. Obs.
h m s	°	°	°	°	
Oct. 5 12 51 18	70.98	0.00	+0.04	71.02	3
12 55 42	68.95	0.00	+0.05	69.00	2
9 13 34 10	231.48	0.00	−0.07	231.41	3
13 37 20	231.27	0.00	−0.07	231.20	2
14 11 30	222.18	0.00	−0.09	222.09	3
14 14 55	221.32	0.00	−0.10	221.22	2
14 35 43	213.40	0.00	−0.13	213.27	3
14 40 28	211.06	0.00	−0.14	210.92	3

Position-Angles of *Phobos* — Cont.

Pac. Standard Time 1894		h	m	s	Observed angle °	Δp °	Δp′ °	Corrected p °	No. Obs.
Oct.	9	14	41	20	209.65	0.00	−0.16	209.49	3
	10	15	37	28	63.15	0.00	+0.04	63.19	3
		15	40	47	61.81	−0.01	+0.04	61.84	3
		15	45	5	60.87	−0.01	+0.04	60.90	4
	12	13	37	22	62.03	0.00	+0.03	62.06	3
		13	40	25	60.93	0.00	+0.03	60.96	4
		13	43	14	59.82	0.00	+0.03	59.85	3
		13	59	59	55.20	0.00	+0.03	55.23	2
		14	2	19	54.57	0.00	+0.03	54.60	3
		14	51	52	42.50	0.00	+0.05	42.55	3
		14	56	10	41.31	0.00	+0.06	41.37	4
		15	0	29	39.72	0.00	+0.06	39.78	3
	16	14	40	43	219.75	0.00	0.00	219.75	2
		14	43	8	218.72	0.00	0.00	218.72	2
		14	46	40	217.22	0.00	0.00	217.22	3
		15	2	54	210.28	0.00	0.00	210.28	4
	25	7	48	37	62.49	+0.01	+0.01	62.51	3
		7	50	21	62.35	+0.01	+0.01	62.37	3
		8	50	7	44.32	0.00	−0.01	44.31	3
		8	51	59	43.66	0.00	−0.01	43.65	3
		8	57	44	41.60	0.00	−0.01	41.59	3
		8	59	19	41.10	0.00	−0.01	41.09	3
		9	42	9	19.20	0.00	−0.03	19.17	3
		9	43	57	17.09	0.00	−0.04	17.05	3
		11	5	6	257.42	0.00	−0.02	257.40	3
		11	11	7	253.57	0.00	−0.02	253.55	3
	27	9	6	24	252.77	+0.01	−0.02	252.76	3
		9	8	57	251.20	0.00	−0.02	251.18	3
		9	12	40	249.36	0.00	−0.02	249.34	4
		10	46	20	220.22	0.00	+0.02	220.24	3
		10	49	55	218.95	0.00	+0.03	218.98	3
		10	53	45	217.72	0.00	+0.03	217.75	3
		10	57	24	216.07	0.00	+0.03	216.10	3
		11	1	29	214.27	0.00	+0.04	214.31	2
		14	20	12	202.70	0.00	+0.06	202.76	3
	30	6	48	8	234.98	+0.02	+0.01	235.01	3
		6	50	7	234.05	+0.02	+0.01	234.08	3
		7	22	53	225.70	+0.01	+0.03	225.74	4
		7	25	35	225.29	+0.01	+0.03	225.33	3
		14	24	50	236.92	−0.01	+0.01	236.92	3
		14	26	12	235.40	−0.01	+0.01	235.40	3
		15	2	18	225.40	0.00	+0.03	225.43	3
		15	8	13	223.47	+0.01	+0.04	223.52	3
Nov.	2	6	45	55	71.39	+0.02	+0.03	71.44	3
		6	50	33	69.84	+0.02	+0.03	69.89	3
		10	10	45	268.05	0.00	−0.14	267.91	3
		10	13	25	264 09	0.00	−0.12	263.97	3
		11	6	43	240.02	0.00	+0.02	240.04	3
		11	10	56	238.57	0.00	+0.02	238.59	3
	6	14	2	59	253.32	−0.01	−0.05	253.26	3
		14	7	49	250.99	−0.01	−0.03	250.95	3
	9	7	3	48	75.05	+0.01	+0.08	75.14	3
		7	7	23	73.78	+0.01	+0.07	73.86	3
		7	55	8	54.55	0.00	−0.08	54.47	3
		7	58	57	53.25	0.00	−0.09	53.16	3
		8	24	27	46.43	0.00	−0.13	46.30	3
		8	27	13	44.56	0.00	−0.15	44.41	3
		9	5	32	29.08	0.00	−0.33	28.75	3
		9	11	30	25.46	0.00	−0.36	25.10	3
	13	7	28	15	236.61	0.00	+0.10	236.71	3
Nov.	13	7	31	5	234.81	0.00	+0.12	234.93	3
		8	5	16	224.01	0.00	+0.22	224.23	3
		8	8	40	222.45	0.00	+0.24	222.69	3
		11	57	35	44.65	0.00	−0.21	44.44	3
		12	0	51	44.02	0.00	−0.22	43.80	3
	14	5	43	26	252.84	+0.03	−0.07	252.80	3
		5	47	1	250.32	+0.03	−0.04	250.31	3
		7	42	21	208.71	0.00	+0.50	209.21	3
		11	34	19	28.22	0.00	−0.48	27.74	3
		11	37	34	26.06	0.00	−0.53	25.53	3
		13	40	17	246.79	−0.01	0.00	246.78	3
		13	44	44	244.57	−0.01	+0.03	244.59	3
		13	58	37	239.76	−0.01	+0.08	239.83	3
		14	2	4	239.09	−0.01	+0.08	239.16	3
	22	5	48	4	236.00	+0.01	+0.21	236.22	3
		5	51	14	234.76	+0.01	+0.21	234.98	3
		9	23	20	60.50	0.00	−0.11	60.39	3
		9	26	53	59.06	0.00	−0.13	58.93	3
		9	43	58	53.81	0.00	−0.20	53.61	3
		9	59	18	49.63	0.00	−0.27	49.36	3
		10	3	17	48.15	0.00	−0.29	47.86	3
		10	17	1	44.00	0.00	−0.36	43.64	3

Distances of *Phobos*.

Pac. Standard Time 1894		h	m	s	Observed distance ″	Δs ″	Δs′ ″	Corrected s ″
Oct.	9	13	47	0	29.80†	+0.01	0.00	29.81
		13	55	45	28.91	+0.01	0.00	28.92
		13	59	55	28.26	+0.01	0.00	28.27
		14	4	5	27.62	+0.01	0.00	27.63
		14	7	55	27.35	+0.01	0.00	27.36
		14	21	45	24.60*	0.00	−0.09	24.51
		14	24	10	24.07	0.00	−0.09	23.98
		14	26	0	23.33	0.00	−0.09	23.24
		14	29	12	22.98	0.00	−0.08	22.90
		14	30	40	22.44	0.00	−0.08	22.36
	10	15	20	22	21.22	0.00	0.00	21.22
		15	22	25	21.96	0.00	0.00	21.96
		15	25	30	22.44	0.00	0.00	22.44
		15	29	17	23.74	0.00	0.00	23.74
		15	32	57	24.38	+0.01	0.00	24.39
	12	13	47	31	27.99	+0.01	0.00	28.00
		13	49	24	28.39	+0.01	0 00	28.40
		13	51	46	28.65	+0.01	0.00	28.66
		13	53	59	29.03	+0.01	0.00	29.04
		13	56	16	29.12	+0.01	0.00	29.13
		15	20	16	21.36	+0.01	0.00	21.37
		15	21	59	20.80	+0.01	0.00	20.81
		15	23	29	20.72	+0.01	0.00	20.73
		15	24	59	20.05	0.00	0.00	20.05
		15	26	14	19.73	0.00	0.00	19.73
		15	28	29	19.01†	+0.02	+0.03	19.06
		15	30	56	18.44‡	+0.01	+0.02	18.47
		15	33	14	17.81*	0.00	0.00	17.81
		15	34	49	17.41	0.00	0.00	17.41
	25	7	53	16	27.67‡	+0.01	−0.02	27.66
		7	54	39	27.68	+0.01	−0.02	27.67
		7	56	24	28.19	+0.01	−0.02	28.18
		7	57	56	28.12	+0.01	−0.02	28.11
		7	59	26	28.42	+0.01	−0.02	28.41

DISTANCES OF *Phobos* — Cont.

Pac. Standard Time 1894				Observed distance	Δs	$\Delta s'$	Corrected s
	h	m	s	″	″	″	″
Oct. 25	8	0	51	28.39	+0.01	—0.02	28.38
	8	2	36	28.54	+0.01	—0.02	28.53
	8	4	1	28.55	+0.01	—0.02	28.54
	8	5	49	28.82	+0.01	—0.02	28.81
	8	7	4	28.92	+0.01	—0.02	28.91
	8	8	54	29.02	+0.01	—0.02	29.01
	8	10	34	29.02	+0.01	—0.02	29.01
	8	11	44	29.49	+0.01	—0.02	29.48
	8	13	4	29.33	+0.01	—0.02	29.32
	8	14	24	29.35	+0.01	—0.02	29.34
	8	16	29	29.56	+0.01	—0.02	29.55
	8	18	16	29.40	+0.01	—0.02	29.39
	8	19	51	29.58	+0.01	—0.02	29.57
	8	21	1	29.59	+0.01	—0.02	29.58
	8	22	1	29.35	+0.01	—0.02	29.34
	8	23	9	29.36	+0.01	—0.02	29.35
	8	25	1	29.67	+0.01	—0.02	29.66
	8	26	6	29.55	+0.01	—0.02	29.54
	8	28	6	29.30	+0.01	—0.02	29.29
	8	29	49	29.34	+0.01	—0.02	29.33
	8	31	29	29.42	+0.01	—0.02	29.41
	8	34	24	29.16	+0.01	—0.02	29.15
	8	36	16	29.00	+0.01	—0.02	28.99
	8	37	14	29.17	+0.01	—0.02	29.16
	8	38	16	29.07	+0.01	—0.02	29.06
	8	42	19	28.66	+0.01	—0.02	28.65
	8	43	26	28.62	+0.01	—0.02	28.61
	8	44	54	28.38	+0.01	—0.02	28.37
	8	46	14	28.08	+0.01	—0.02	28.07
	9	6	1	25.02	+0.01	—0.02	25.01
	9	7	19	24.89	+0.01	—0.02	24.88
	9	10	24	24.23	+0.01	—0.02	24.22
	9	11	56	23.84	+0.01	—0.02	23.83
	9	13	49	23.54	+0.01	—0.02	23.53
	9	14	46	23.51	+0.01	—0.02	23.50
	9	15	46	23.23	+0.01	—0.02	23.22
	9	16	59	22.95	+0.01	—0.02	22.94
	9	18	6	22.63	+0.01	—0.02	22.62
	9	19	26	22.24	+0.01	—0.02	22.23
	9	20	26	22.03	+0.01	—0.02	22.02
	9	21	29	21.94	+0.01	—0.02	21.93
	9	22	24	21.84	+0.01	—0.02	21.83
	9	23	31	21.43	+0.01	—0.02	21.42
	9	24	36	21.09	+0.01	—0.02	21.08
	9	25	36	21.01	+0.01	—0.02	21.00
	9	26	39	20.49	+0.01	—0.02	20.48
	9	27	39	20.26	+0.01	—0 02	20.25
	9	29	4	19.95	+0.01	—0.02	19.94
	9	30	6	19.65	+0.01	—0.02	19.64
	9	33	14	18.93	+0.01	—0.01	18.93
	9	34	14	18.68	+0.01	—0.01	18.68
	9	35	21	18.48	+0.01	—0.01	18.48
	9	36	26	17.90	+0.01	—0.01	17.90
	9	38	4	17.71	+0.01	—0.01	17.71
	9	39	26	17.12	0.00	—0.01	17.11
27	9	50	52	27.43	+0.01	+0.04	27.48
	9	53	39	28.02	+0.01	+0.04	28.07
	9	57	35	28.11	+0.01	+0.04	28.16
	10	0	14	28.10	+0.01	+0.04	28.15
	10	2	52	28.40	+0.01	+0.04	28.45
	10	4	52	28.26	+0.01	+0.04	28.31

DISTANCES OF *Phobos* — Cont.

Pac. Standard Time 1894				Observed distance	Δs	$\Delta s'$	Corrected s
	h	m	s	″	″	″	″
Oct. 27	10	9	29	28.45	+0.01	+0.04	28.50
	10	12	9	28.22	+0.01	+0.04	28.27
	10	15	14	28.10	+0.01	+0.04	28.15
	10	17	15	27.97	+0.01	+0.04	28.02
	10	19	12	27.61	+0.01	+0.04	27.66
	10	21	22	27.56	+0.01	+0.04	27.61
	10	24	10	27.42	+0.01	+0.04	27.47
	10	26	9	27.29	+0.01	+0.04	27.34
	10	28	37	26.98	+0.01	+0.04	27.03
	10	36	34	26.02	+0.01	+0.04	26.07
	10	38	2	25.69	+0.01	+0.04	25.74
	10	39	52	25.34	+0.01	+0.04	25.39
	10	41	40	25.20	+0.01	+0.04	25.25
	10	43	25	24.75	+0.01	+0.04	24.80
	11	5	44	20.14	+0.01	+0.03	20.18
	11	8	7	19.93	+0.01	+0.03	19.97
	11	9	49	19.23	+0.01	+0.03	19.27
	11	12	25	18.72	+0.01	+0.03	18.76
	11	16	4	17.88	+0.01	+0.03	17.92
30	6	55	0	27.55	+0.01	+0.06	27.62
	6	56	57	27.46	+0.01	+0.06	27.53
	6	58	17	27.47	+0.01	+0.06	27.54
	6	59	46	27.55	+0.01	+0.06	27.62
	7	1	35	27.58	+0.01	+0.06	27.65
	7	3	17	27.53	+0.01	+0.06	27.60
	7	4	55	27.51	+0.01	+0.06	27.58
	7	6	42	27.63	+0.01	+0.06	27.70
	7	8	40	27.32	+0.01	+0.06	27.39
	7	10	32	27.11	+0.01	+0.06	27.18
	7	11	42	27.21	+0.01	+0.06	27.28
	7	13	20	27.09	+0.01	+0.06	27.16
	7	15	45	27.01	+0.01	+0.06	27.08
	7	19	32	26.63	+0.01	+0.06	26.70
	14	34	5	27.43	+0.02	+0.06	27.51
	14	36	5	27.72	+0.02	+0.06	27.80
	14	38	27	27.64	+0.02	+0.06	27.72
	14	40	47	27.40	+0.02	+0.06	27.48
	14	43	47	27.40	+0.02	+0.06	27.48
	14	46	12	27.26	+0.02	+0.06	27.34
	14	48	35	27.31	+0.03	+0.06	27.40
	14	52	35	26.81	+0.03	+0.06	26.90
	14	55	57	26.37	+0.03	+0.06	26.46
Nov. 2	6	58	9	24.47	+0.01	—0.10	24.38
	7	16	28	26.75	+0.01	—0.10	26.66
	7	22	33	27.55	+0.01	—0.10	27.46
	7	24	55	27.74	+0.01	—0.10	27.65
	7	26	23	27.74	+0.01	—0.10	27.65
	7	32	18	27.96	+0.01	—0.10	27.87
	7	34	53	28.37	+0.01	—0.10	28.28
	7	36	15	28.09	+0.01	—0.10	28.00
	7	38	0	28.23	+0.01	—0.10	28.14
	7	40	38	28.23	+0.01	—0.10	28.14
	7	42	40	28.26	+0.01	—0.10	28.17
	7	44	3	28.36	+0.01	—0.10	28.27
	7	45	23	28.22	+0.01	—0.10	28.13
	7	46	35	28.24	+0.01	—0.10	28.15
	7	47	45	28.03	+0.01	—0.10	27.94
	7	49	35	28.09	+0.01	—0.10	28.00
	7	50	55	28.10	+0.01	—0.10	28.01
	7	51	48	27.76	+0.01	—0.10	27.67
	8	3	48	26.87	+0.01	—0.10	26.78

Distances of *Phobos* — Cont.

Pac. Standard Time 1894		Observed distances	Δs	Δs′	Corrected s
	h m s	″	″	″	″
Nov. 2	8 5 10	27.00	+0.01	—0.10	26.91
	8 7 13	26.50	+0.01	—0.10	26.41
	8 9 53	26.43	+0.01	—0.10	26.34
	10 16 13	16.14	0.00	+0.10	16.24
	10 18 28	16.81	0.00	+0.10	16.91
	10 20 0	17.12	0.00	+0.10	17.22
	10 21 18	17.70	0.00	+0.10	17.80
	10 23 23	17.88	0.00	+0.10	17.98
	11 15 33	26.80	+0.01	+0.10	26.91
	11 17 23	26.95	+0.01	+0.10	27.06
	11 19 10	26.97	+0.01	+0.10	27.08
	11 21 3	26.92	+0.01	+0.10	27.03
	11 23 3	27.14	+0.01	+0.10	27.25
	11 24 33	27.06	+0.01	+0.10	27.17
	11 26 18	27.13	+0.01	+0.10	27.24
	11 29 30	27.20	+0.01	+0.10	27.31
	11 31 53	27.08	+0.01	+0.10	27.19
	11 33 10	27.13	+0.01	+0.10	27.24
	11 35 43	27.07	+0.01	+0.10	27.18
	11 38 8	26.82	+0.01	+0.10	26.93
	11 40 8	26.72	+0.01	+0.10	26.83
	11 42 0	26.50	+0.01	+0.10	26.61
	11 44 53	26.60	+0.01	+0.10	26.71
	11 46 55	26.53	+0.01	+0.10	26.64
	11 48 58	26.39	+0.01	+0.10	26.50
6	14 42 57	25.49	+0.02	+0.16	25.67
	14 45 19	25.77	+0.02	+0.16	25.95
	14 47 24	25.36	+0.02	+0.16	25.54
	14 50 54	25.33	+0.02	+0.16	25.51
	14 51 37	25.61	+0.03	+0.16	25.80
	14 58 31	25.83	+0.03	+0.16	26.02
9	7 11 27	21.98	+0.01	—0.20	21.79
	7 23 54	23.80	+0.01	—0.20	23.61
	7 26 10	24.01	+0.01	—0.20	23.82
	7 29 33	24.88	+0.01	—0.20	24.69
	7 33 45	24.96	+0.01	—0.20	24.77
	7 36 55	25.66	+0.01	—0.20	25.47
	7 40 45	25.52	+0.01	—0.20	25.33
	7 43 55	25.63	+0.01	—0.20	25.44
	7 47 35	26.44	+0.01	—0.20	26.25
	8 3 25	26.73	+0.01	—0.19	26.55
	8 6 5	26.63	+0.01	—0.19	26.45
	8 9 2	26.26	+0.01	—0.19	26.08
	8 13 25	26.22	+0.01	—0.19	26.04
	8 16 27	26.45	+0.01	—0.19	26.27
	8 18 22	26.17	+0.01	—0.19	25.99
	9 16 50	17.05	0.00	—0.10	16.95
	9 19 50	16.50	0.00	—0.10	16.40
10	6 15 11	26.40	+0.01	—0.22	26.19
	6 17 16	26.40	+0.01	—0.22	26.19
	6 50 31	26.83	+0.01	—0.22	26.62
	6 53 43	26.36	+0.01	—0.22	26.15
	6 56 6	26.20	+0.01	—0.22	25 99
	7 0 3	26.48	+0.01	—0.22	26.27
	7 3 21	26.41	+0.01	—0.22	26.20
	7 5 13	26.44	+0.01	—0.22	26 23
	10 38 5	24.95	+0.01	+0.22	25 18
	10 40 35	24.88	+0.01	+0.22	25.11
	10 42 57	24.97	+0 01	+0.22	25.20
	10 45 17	25.10	+0.01	+0.22	25.33
	10 47 55	25.14	+0.01	+0.22	25.37

Distances of *Phobos* — Cont.

Pac. Standard Time 1894		Observed distances	Δs	Δs′	Corrected s
	h m s	″	″	″	″
Nov. 10	10 50 22	25.02	+0.01	+0.22	25.25
	10 52 17	25.04	+0.01	+0.22	25.27
	10 54 30	24.98	+0.01	+0.22	25.21
	10 56 35	25.00	+0.01	+0.22	25.23
	10 59 17	24.94	+0.01	+0.21	25.16
	11 2 15	24.72	+0.01	+0.21	24.94
	11 4 35	24.68	+0.01	+0.21	24.90
	11 6 7	24.52	+0.01	+0.21	24.74
	11 10 0	24.06	+0.01	+0.21	24.28
13	7 34 28	24.21	+0.01	+0.26	24.48
	7 36 40	24.45	+0.01	+0.25	24.71
	7 38 55	24.75	+0.01	+0.25	25.01
	7 41 3	24.52	+0.01	+0.25	24.78
	7 43 33	24.42	+0.01	+0.25	24.68
	7 45 33	24.51	+0.01	+0.25	24.77
	7 48 25	24.31	+0.01	+0.25	24.57
	7 51 58	24.13	+0.01	+0.25	24.39
	7 54 3	24.06	+0.01	+0.24	24.31
	7 55 45	23.96	+0.01	+0.24	24.21
	7 58 0	23.65	+0.01	+0.24	23.90
	8 0 10	23.77	+0.01	+0.24	24.02
	8 2 15	23.46	+0.01	+0.24	23.71
	11 33 53	26.03	+0.01	—0.25	25.79
	11 36 5	25.86	+0.01	—0.25	25.62
	11 37 30	25.76	+0.01	—0.25	25.52
	11 39 35	25.82	+0.01	—0.25	25.58
	11 42 28	25.58	+0.01	—0.25	25.34
	11 44 38	25.53	+0.01	—0.24	25.30
	11 46 13	25.51	+0.01	—0.24	25.28
	11 47 50	25.34	+0.01	—0.24	25.11
	11 50 13	25.28	+0.01	—0.24	25.05
	11 52 35	24.89	+0.01	—0.24	24.66
14	5 51 41	20.18	+0.01	+0.28	20.47
	5 54 26	20.35	+0.01	+0.28	20.64
	5 57 13	21.00	+0.01	+0.28	21.29
	6 0 31	21.35	+0.01	+0.28	21.64
	6 2 38	21.86	+0.01	+0.28	22.15
	6 4 41	21.72	+0.01	+0.28	22.01
	6 31 24	23.98	+0.01	+0.28	24.27
	6 33 17	24.17	+0 01	+0 28	24.46
	6 34 44	23.89	+0.01	+0.27	24.17
	6 36 14	24.24	+0.01	+0.27	24.52
	6 38 37	24.22	+0.01	+0.27	24.50
	6 41 42	24.25	+0.01	+0.27	24.53
	6 43 42	24.28	+0.01	+0.27	24.56
	6 45 4	24.38	+0.01	+0.27	24.66
	6 46 20	24.09	+0.01	+0.27	24.37
	6 48 23	24 08	+0.01	+0.27	24.36
	6 49 58	24.05	+0 01	+0.27	24.33
	6 51 58	23.91	+0.01	+0.27	24.19
	7 16 33	16.47	+0.01	+0.17	16.65
	7 48 18	15.64	0.00	+0.16	15.80
	7 50 35	15.09	0.00	+0.16	15.25
	7 52 30	14.65	0.00	+0.15	14.80
	10 21 30	25.26	+0.01	—0.28	24.99
	10 23 10	25.34	+0.01	—0.28	25.07
	10 25 0	25.45	+0.01	—0.28	25.18
	10 26 52	25.52	+0.01	—0.27	25.26
	10 28 20	25.45	+0.01	—0.27	25.19
	10 30 20	25.42	+0.01	—0.27	25.16
	10 31 42	25.28	+0.01	—0.27	25.02

DISTANCES OF *Phobos* — Cont.

Pac. Standard Time 1894	h	m	s	Observed distances	Δs	Δs′	Corrected s
				″	″	″	″
Nov. 14	10	33	2	25.42	+0.01	—0.27	25.16
	10	34	15	25.33	+0.01	—0.27	25.07
	10	35	22	25.50	+0.01	—0.27	25.24
	11	41	57	16.34	+0.01	—0.16	16.19
	11	44	30	15.72	+0.01	—0.15	15.58
	11	49	42	14.71	+0.01	—0.14	14.58
	13	18	4	17.86	+0.01	+0.28	18.15
	13	25	16	19.01	+0.01	+0.28	19.30
	13	28	34	19.53	+0.02	+0.28	19.83
	13	34	19	20.45	+0.02	+0.28	20.75
	14	9	9	24.26	+0.03	+0.28	24.57
	14	13	4	23.75	+0.04	+0.27	24.06
	14	16	9	24.25	+0.04	+0.27	24.56
	14	20	1	24.29	+0.04	+0.27	24.60
22	5	54	49	21.83	+0.01	+0.38	22.22
	5	56	42	21.78	+0.01	+0.38	22.17
	6	0	59	21.74	+0.01	+0.37	22.12
	6	6	4	21.92	+0.01	+0.37	22.30
	9	31	50	23.11	+0.01	—0.39	22.73
	9	34	52	23.40	+0.01	—0.39	23.02
	9	37	7	23.49	+0.01	—0.39	23.11
	9	40	32	23.28	+0.01	—0.38	22.91
	9	47	10	23.63	+0.01	—0.38	23.26
	9	49	20	23.48	+0.01	—0.38	23.11
	9	51	18	23.68	+0.01	—0.37	23.32
	9	54	0	23.58	+0.01	—0.37	23.22
	10	7	28	23.03	+0.01	—0.35	22.69
	10	9	21	22.94	+0.01	—0.35	22.60
	10	11	8	22.70	+0.01	—0.35	22.36
	10	12	56	22.57	+0.01	—0.35	22.23

POSITION-ANGLES OF *Deimos*.

Pac. Standard Time 1894	h	m	s	Observed angle	Δp	Δp′	Corrected p	No. Obs.
				°	°	°	°	
Oct 5	12	41	10	95.07	0.00	—0.05	95.02	3
	12	44	42	93.86	0.00	—0.05	93.81	2
	13	1	10	89.10	0.00	—0.03	89.07	3
	13	5	42	88.20	0.00	—0.03	88 17	2
10	14	23	38	85.54	0.00	0.00	85.54	3
	14	27	0	84.68	0.00	0.00	84.68	2
	14	47	35	80.45	—0.01	0.00	80.44	2
	14	51	13	79.57	—0.01	0.00	79.56	3
	16	4	45	68.63	—0.01	+0.01	68.63	3
	16	7	50	68.30	—0.01	+0.01	68.30	2
	16	36	47	65.39	—0.01	+0.01	65.39	3
11	8	6	56	243.91	+0.04	—0.01	243.94	3
	8	9	29	243.56	+0.03	—0.01	243.58	3
	8	15	46	242.84	+0.03	—0.01	242.86	4
	8	44	39	240.76	+0.02	—0.02	240.76	3
	8	49	23	240.25	+0.02	—0.02	240.25	3
	8	53	17	240.18	+0.02	—0.02	240.18	4
	9	20	28	238.01	+0.01	—0.02	238.00	3
	9	24	40	237.65	+0.01	—0.02	237.64	4
	9	28	16	237.24	+0.01	—0.02	237.23	3
	10	15	19	234.31	0 00	—0.02	234.29	3
	10	20	8	234.21	0.00	—0.02	234.19	4
	10	23	46	233.90	0.00	—0.02	233.88	3
	10	47	14	232.62	0.00	—0.02	232.60	3
	10	50	1	232.31	0.00	—0.02	232.29	2
	11	21	11	230.50	0.00	—0.02	230.48	3

POSITION-ANGLES OF *Deimos* — Cont.

Pac. Standard Time 1894	h	m	s	Observed angle	Δp	Δp′	Corrected p	No. Obs.
				°	°	°	°	
Oct. 11	11	24	31	230.12	0.00	—0.02	230.10	2
	11	44	41	228.72	0.00	—0.02	228.70	2
	11	47	21	228.59	0.00	—0.02	228.57	3
12	8	35	44	358.13	—0.02	+0.09	358.20	3
	8	39	41	356.42	—0.02	+0.09	356.49	3
	8	47	15	352.52	—0.02	+0.09	352.59	4
	9	18	12	337.11	—0.01	+0.09	337.19	3
	9	21	1	335.11	—0.01	+0.09	335.22	4
	9	21	19	332.67	—0.01	+0.09	332.75	3
	9	17	29	318.17	0.00	+0.07	318.24	3
	9	50	45	316.64	0.00	+0.07	316.71	4
	9	54	7	314.11	0.00	+0.07	314.18	3
	10	19	22	299.25	0.00	+0.05	299.30	3
	10	21	25	298.66	0.00	+0.05	298.71	4
	10	23	21	297.75	0.00	+0.05	297.80	3
	15	54	11	237.18	—0.01	—0.01	237.16	3
	15	57	41	237.07	—0.01	—0.01	237.05	2
	16	28	59	234.96	—0.01	—0.01	234.94	2
	16	31	54	234.75	—0.01	—0.01	234.73	3
24	12	33	9	74.88	0.00	+0.01	74.89	3
	12	37	49	74.20	0.00	+0.01	74.21	3
	13	14	2	69.83	0.00	0.00	69.83	3
	13	20	29	68.84	0.00	0.00	68.81	3
25	6	44	27	237.35	+0.04	0.00	237.39	3
	6	46	54	237.09	+0.04	0.00	237.13	3
	7	8	39	235.99	+0.02	0.00	236 01	3
	7	11	29	235.65	+0.02	0.00	235.67	3
	7	24	12	234.54	+0.02	0.00	234.56	3
	7	26	26	234.30	+0.02	0.00	234.32	3
	7	44	59	233.15	+0.01	0.00	233.16	3
27	6	40	12	46.59	+0.02	—0.01	16.60	3
	6	44	52	46.37	+0.02	—0.01	46.38	3
	8	12	25	39.02	—0.01	—0.01	39.00	3
	8	16	37	38.27	—0.01	—0.01	38.25	3
	8	43	39	35.55	0.00	—0.01	35.51	3
	8	47	32	35.37	0.00	—0.01	35.36	3
	12	2	7	349.35	0.00	—0.06	349.29	3
	12	9	22	346.17	0.00	—0.06	346.11	3
	12	14	40	343.53	0.00	—0.06	343.47	4
	12	46	17	327.20	0.00	—0.07	327.13	3
	12	51	54	323.77	0.00	—0 07	323.70	3
	12	56	2	321.72	0.00	—0.07	321.65	4
	13	23	7	306.94	0.00	—0.06	306.88	3
	13	31	17	303.00	0.00	—0.06	302.94	3
	13	37	1	300.32	0.00	—0.06	300.26	4
30	6	23	28	245.34	+0.01	0.00	245.38	3
	6	26	42	244.64	+0.04	0.00	244.68	3
	7	46	15	237.75	+0.01	0.00	237.76	3
	7	49	52	237.52	+0.01	0 00	237.53	3
	8	13	28	235.95	0.00	+0.01	235.96	3
	8	16	0	235.56	0.00	+0.01	235.57	3
Nov. 2	8	21	40	78.39	+0.01	+0.03	78.43	3
	8	26	43	77.50	+0.01	+0.03	77.54	3
6	12	23	2	22.00	0.00	—0.13	21.87	3
	12	29	22	20.49	0.00	—0.14	20.35	3
	12	58	40	14.34	0.00	—0.17	14.17	3
	13	3	45	13.15	0.00	—0.18	12.97	3
	13	36	49	3.32	+0.01	—0.23	3.10	3
7	12	46	23	57.49	0.00	—0.02	57.47	3
	12	50	43	57.10	0.00	—0.02	57.08	3
	13	23	20	54.60	0.00	—0.03	54.57	3

Position-Angles of *Deimos*.

Pac. Standard Time 1894	Observed angle	Δp	Δp′	Corrected p	No. Obs.
h m s	°	°	°	°	
Nov. 7 13 26 35	54.30	0.00	—0.03	54.27	3
14 9 38	51.22	0.00	—0.03	51.19	3
14 13 5	50.94	0.00	—0.04	50.90	3
14 51 41	47.90	0.00	—0.04	47.86	3
15 2 20	46.99	+0.01	—0.04	46.96	3
9 6 27 53	263.10	+0.02	—0.07	263.05	3
6 32 23	261.98	+0.02	—0.07	261.93	3
9 30 37	241.35	0.00	+0.01	241.36	3
9 35 17	240.83	0.00	+0.01	240.84	3
10 11 27 44	283.95	0.00	—0.21	283.74	3
11 32 45	282.25	0.00	—0.20	282.05	3
13 5 45 4	234.31	+0.02	+0.05	234.38	3
6 25 19	231.78	+0.01	+0.06	231.85	3
7 6 39	228.20	0.00	+0.07	228.27	3
14 6 20 59	282.91	+0.01	—0.26	282.66	3
6 26 27	281.04	+0.01	—0.25	280.80	3
8 3 5	258.98	0.00	—0.07	258.91	3
8 7 10	258.28	0.00	—0.06	258.22	3
12 0 47	235.07	0.00	+0.05	235.12	3
12 5 0	234.79	0.00	+0.05	234.84	3
12 36 39	232 57	0.00	+0.06	232.63	3
12 40 35	232.02	0.00	+0.06	232.08	3
22 11 13 8	103.96	0.00	+0.42	104.38	3
11 24 28	99.78	—0.01	+0.37	100.14	3

Distances of *Deimos*.

Pac. Standard Time 1894	Observed distances	Δs	Δs′	Corrected s
h m s	″	″	″	″
Oct. 10 14 34 57	39.75*	+0.01	0.00	39.76
14 37 12	40.44	+0.01	0.00	40.45
14 39 45	40.75	+0.01	0.00	40.76
14 41 40	41.07	+0.01	0.00	41.08
14 44 5	41.38	+0.01	0.00	41.39
15 1 22	44.47	+0.01	0.00	44.48
15 4 0	44.97	+0.01	0.00	44.98
15 6 55	45.56	+0.01	0.00	45.57
15 9 20	46.07	+0.01	0.00	46.08
15 11 50	46.37	+0.01	0.00	46.38
16 12 12	56.42	+0.03	0.00	56.45
16 14 50	56.51	+0.03	0.00	56.54
16 23 25	57.92	+0.03	0.00	57.95
16 30 35	59.23	+0.04	0.00	59.27
16 33 17	59.34	+0.04	0.00	59.38
16 43 12	61.10	+0.05	0.00	61.15
16 46 32	61.69	+0.05	0.00	61.74
16 50 37	62.08	+0.05	0.00	62.13
16 51 32	62.54	+0.06	0.00	62.60
16 58 20	63.11	+0.06	0.00	63.17
11 8 25 26	65.69	+0.02	—0.10	65.61
8 27 58	65.43	+0.02	—0.10	65.35
8 30 36	65.75	+0.02	—0.10	65.67
8 34 6	66.44	+0.02	—0.10	66.36
8 37 11	66.68	+0.02	—0.10	66.60
8 59 36	67.94	+0.02	—0.10	67.86
9 2 48	68.56	+0 02	—0.10	68.48
9 6 56	68.50	+0.02	—0.10	68.42
9 10 23	68.84	+0.02	—0.10	68.76
9 13 1	69.39	+0.02	—0.10	69.31
9 33 21	71.87	+0 02	—0.10	71.79
9 35 48	72.00	+0.02	—0.10	71.92

Distances of *Deimos* — Cont.

Pac. Standard Time 1894	Observed distances	Δs	Δs′	Corrected s
h m s	″	″	″	″
Oct. 11 9 38 48	72.07	+0.02	—0.10	71.99
9 41 11	72.37	+0.02	—0.10	72.29
9 43 51	72.58	+0.02	—0.10	72.50
10 30 8	74.34	+0.02	—0.09	74.27
10 33 26	74.39	+0.02	—0.09	74.32
10 35 53	74.34	+0.02	—0.09	74.27
10 38 11	74.39	+0.02	—0.09	74 32
10 42 43	74.64	+0.02	—0.09	74.57
10 53 58	74.79	+0.02	—0.09	74.72
10 56 23	75.05	+0.02	—0.09	74.98
10 59 1	74.72	+0.02	—0.09	74.65
11 1 33	74.99	+0.02	—0.09	74.92
11 3 36	75.03	+0.02	—0.09	74.96
11 6 23	75.07	+0.02	—0.09	75.00
11 10 1	74.97	+0.02	—0.09	74.90
11 13 13	74.97	+0.02	—0.09	74.90
11 28 1	74.56	+0.02	—0.08	74.50
11 30 41	74.65	+0.02	—0.08	74.59
11 33 16	74.55	+0.02	—0.08	74.49
11 34 53	74.49	+0.02	—0.08	74.43
11 37 51	74.55	+0.02	—0.08	74.49
11 51 43	73.84	+0.02	—0.08	73.78
11 55 11	73.96	+0.02	—0.08	73.90
12 8 54 19	26.77	+0.01	0.00	26.78
8 57 11	26.66	+0.01	0.00	26.67
8 58 34	26.26	+0.01	0.00	26.27
9 0 4	26.26	+0.01	0.00	26.27
9 2 46	25.68	+0.01	0.00	25.69
9 6 14	25.44†	+0.02	0.00	25.46
9 7 46	25.38	+0.02	0.00	25.40
9 8 46	25.50	+0.02	0.00	25.52
9 10 21	25.19	+0.02	0.00	25.21
9 12 4	24.83	+0.02	0.00	24.85
9 28 49	23.57	+0.02	0.00	23.59
9 30 46	23.40	+0.02	0.00	23.42
9 33 1	23.87	+0.02	0.00	23.89
9 34 46	23.51	+0.02	0.00	23.53
9 36 6	23.84	+0.02	0.00	23.86
9 39 14	23.83*	+0.01	—0.02	23.82
9 40 49	23.66	+0.01	—0.03	23.64
9 41 51	23.90	+0.01	—0.03	23.88
9 43 6	23.53	+0.01	—0.03	23.51
9 44 31	23.84	+0.01	—0.03	23.82
9 57 26	24.33	+0.01	—0.04	24.30
9 58 34	24.43	+0.01	—0.04	24.40
9 59 36	23.93	+0.01	—0.04	23.90
10 0 19	24.14	+0.01	—0.04	24.11
10 1 9	24.42	+0.01	—0.04	24.39
10 2 36	24.13†	+0.02	0.00	24.15
10 3 31	24.58	+0.02	0.00	24.60
10 5 16	24.64	+0.02	0.00	24.66
10 6 44	24.38	+0.02	0.00	24.40
10 8 6	24.64	+0.02	0.00	24.66
16 3 9	72.39*	+0.04	—0.07	72.36
16 6 39	72.36	+0.05	—0.07	72.34
16 10 34	73.24‡	+0.06	—0.03	73.27
16 14 46	73.55†	+0.07	0.00	73.62
16 17 41	73.37	+0.07	0.00	73.44
16 39 7	74.49	+0.09	0.00	74.58
16 46 6	74.77	+0.09	0.00	74.86
16 48 39	75.01‡	+0.09	—0.03	75.07

DISTANCES OF *Deimos.* — Cont.

Pac. Standard Time 1894				Observed distances	Δs	Δs′	Corrected s
	h	m	s	″	″	″	″
Oct. 12	16	54	36	74.87*	+0.09	—0.07	74.89
	16	59	59	75.16	+0.09	—0.07	75.18
25	6	52	21	71.22	+0.02	0.00	71.24
	6	55	9	70.99‡	+0.03	+0.02	71.04
	6	57	11	71.06†	+0.03	+0.04	71.13
	6	59	41	71.09	+0.03	+0.04	71.16
	7	1	31	71.27‡	+0.03	+0.02	71.32
	7	3	56	71.42*	+0.02	0.00	71.44
	7	14	49	71.62	+0.02	0.00	71.64
	7	16	54	71.71‡	+0.02	+0.02	71.75
	7	18	4	71.73†	+0.03	+0.04	71.80
	7	19	29	72.01	+0.03	+0.04	72.08
	7	20	44	71.74‡	+0.02	+0.02	71.78
	7	22	1	72.04*	+0.02	0.00	72.06
	7	30	4	72.28	+0.02	0.00	72.30
	7	31	56	72.11‡	+0.02	+0.02	72.15
	7	35	4	72.10†	+0.02	+0.04	72.16
	7	36	46	72.03	+0.02	+0.04	72.09
	7	39	24	72.17‡	+0.02	+0.02	72.21
	7	41	46	72.63*	+0.02	0.00	72.65
27	6	53	7	68.65‡	+0.02	—0.04	68.63
	6	57	24	67.78	+0.02	—0.04	67.76
	6	59	57	67.57	+0.02	—0.04	67.55
	8	22	54	60.11	+0.01	—0.03	60.09
	8	25	10	60.15	+0.01	—0.03	60.13
	8	27	29	59.70	+0.01	—0.03	59.68
	8	29	55	59.34	+0.01	—0.03	59.32
	8	32	2	58.97	+0.01	—0.03	58.95
	8	34	29	58.72	+0.01	—0.03	58.70
	8	37	22	58.50	+0.01	—0.03	58.48
	8	39	57	57.98	+0.01	—0.03	57.96
	12	20	37	27.07	+0.01	—0.01	27.07
	12	23	49	26.90	+0.01	0.00	26.91
	12	27	26	26.60	+0.01	0.00	26.61
	12	33	12	25.98	+0.01	0.00	25.99
	12	35	44	26.40	+0.01	0.00	26.41
	12	40	42	25.98	+0.01	0.00	25.99
	13	2	42	25.76	+0.01	0.00	25.77
	13	7	14	25.62	+0.01	0.00	25.63
	13	10	42	25.90	+0.01	0.00	25.91
	13	13	27	25.97	+0.01	0.00	25.98
	13	16	34	25.89	+0.01	0.00	25.90
	13	18	52	26.39	+0.01	0.00	26.40
30	6	32	2	62.17	+0.03	+0.06	62.26
	6	34	38	62.02	+0.03	+0.06	62.11
	6	41	7	63.04	+0.03	+0.06	63.13
	6	43	5	63.50	+0.03	+0.06	63.59
	7	55	7	68.57	+0.02	+0.06	68.65
	7	57	38	68.98	+0.02	+0.06	69.06
	8	0	30	68.67	+0.02	+0.06	68.75
	8	3	30	69.11	+0.02	+0.06	69.19
	8	5	57	69.08	+0.02	+0.06	69.16
	8	8	35	69.49	+0.02	+0.06	69.57
	8	47	50	70.39	+0.02	+0.06	70.47
	8	51	20	70.18	+0.02	+0.06	70.26
	8	53	27	70.27	+0.02	+0.06	70.35
	8	56	55	70.32	+0.02	+0.06	70.40
	9	1	55	70.29	+0.02	+0.06	70.37
	9	9	2	70.30	+0.02	+0.06	70.38
Nov. 2	8	31	40	49.01	+0.01	—0.10	48.92
	8	34	43	49.31	+0.01	—0.10	49.22

DISTANCES OF *Deimos* — Cont.

Pac. Standard Time 1894				Observed distances	Δs	Δs′	Corrected s
	h	m	s	″	″	″	″
Nov. 2	8	38	10	49.64	+0.01	—0.10	49.55
	8	44	30	50.85	+0.01	—0.10	50.76
	8	47	35	51.25	+0.01	—0.10	51.16
	8	50	5	51.50	+0.01	—0.10	51.41
6	12	37	29	40.14	+0.02	—0.08	40.08
	12	40	22	39.81	+0.02	—0.08	39.75
	12	43	4	39.09	+0.02	—0.08	39.03
	12	45	12	39.07	+0.02	—0.07	39.02
	12	47	42	38.47	+0.02	—0.07	38.42
	12	50	12	38.34	+0.02	—0.07	38.29
	13	45	34	30.63	+0.01	—0.03	30.61
	13	48	59	30.16	+0.01	—0.03	30.14
	13	52	27	29.99	+0.01	—0.02	29.98
	14	19	4	27.01	+0.01	—0.01	27.01
	14	22	52	26.73	+0.01	—0.01	26.73
	14	27	29	26.72	+0.01	—0.01	26.72
	14	31	19	26.46	+0.01	0.00	26.47
	14	38	32	26.09	+0.01	0.00	26.10
7	12	57	55	65.71	+0.03	—0.18	65.56
	13	1	43	65.68	+0.03	—0.18	65.53
	13	4	25	65.76	+0.03	—0.18	65.61
	13	6	20	65.80	+0.04	—0.18	65.66
	13	9	5	65.58	+0.04	—0.18	65.44
	13	12	10	65.78	+0.04	—0.17	65.65
	13	16	45	66.07	+0.04	—0.17	65.94
	13	31	0	66.48	+0.04	—0.17	66.35
	13	34	40	66.53	+0.05	—0.17	66.41
	13	39	15	66.49	+0.05	—0.17	66.37
	13	42	50	66.88	+0.05	—0.17	66.76
	13	49	5	66.75	+0.05	—0.17	66.63
	13	53	30	66.32	+0.05	—0.17	66.20
	13	58	0	66.42	+0.06	—0.17	66.31
	14	0	58	66.52	+0.06	—0.17	66.41
	14	18	33	66.06	+0.07	—0.17	65.96
	14	22	50	65.98	+0.08	—0.17	65.89
	14	31	45	66.24	+0.09	—0.17	66.16
	14	38	10	66.05	+0.09	—0.17	65.97
	14	45	18	65.14	+0.10	—0.16	65.08
9	6	41	35	42.61	+0.02	+0.19	42.82
	6	46	15	43.66	+0.02	+0.20	43.88
	6	53	55	44.64	+0.02	+0.20	44.86
	6	58	20	44.67	+0.02	+0.20	44.89
	9	41	12	61.65	+0.02	+0.20	61.87
	9	45	7	61.89	+0.02	+0.20	62.11
	9	48	48	62.53	+0.02	+0.20	62.75
	9	51	33	62.25	+0.02	+0.20	62.47
	9	59	27	63.01	+0.02	+0.20	63.23
	10	3	55	62.94	+0.02	+0.20	63.16
13	5	51	42	61.90	+0.02	+0.26	62.18
	5	59	29	62.09	+0.02	+0.26	62.37
	6	5	47	62.31	+0.02	+0.26	62.59
	6	10	17	62.15	+0.02	+0.25	62.42
	6	15	17	62.10	+0.02	+0.25	62.37
	6	19	9	62.67	+0.02	+0.25	62.94
	7	13	30	60.89	+0.01	+0.24	61.14
	7	15	48	60.81	+0.01	+0.24	61.06
	7	19	3	60.40	+0.01	+0.24	60.65
	7	22	6	60.66	+0.01	+0.24	60.91
14	6	55	50	34.04	+0.01	+0.23	34.28
	6	58	58	33.87	+0.01	+0.23	34.11
	7	2	25	34.60	+0.01	+0.24	34.85

DISTANCES OF *Deimos* — Cont.

Pac. Standard Time 1894		Observed distances	Δs	Δs′	Corrected s
	h m s	″	″	″	″
Nov. 14	8 13 49	43.51	+0.01	+0.28	43.80
	8 15 31	44.01	+0.01	+0.28	44.30
	8 17 11	44.26	+0.01	+0.28	44.55
	8 18 17	44.72	+0.01	+0.28	45.01
	8 20 29	44.68	+0.01	+0.28	44.97
	12 13 40	61.80	+0.02	+0.27	62.09
	12 20 12	61.58	+0.02	+0.27	61.87
	12 23 42	61.90	+0.02	+0.27	62.19
	12 25 27	61.59	+0.02	+0.27	61.88
	12 27 22	61.78	+0.02	+0.27	62.07
	12 29 32	61.62	+0.02	+0.27	61.91
	12 32 7	61.79	+0.02	+0.27	62.08
22	11 31 36	29.14	+0.01	−0.31	28.84
	11 36 31	30.26	+0.01	−0.32	29.95
	11 40 18	30.46	+0.01	−0.33	30.14
	11 43 34	31.00	+0.01	−0.33	30.68
	11 46 29	31.13	+0.01	−0.34	30.80
	11 51 26	31.50	+0.01	−0.35	31.16
22	11 56 11	32.25	+0.01	−0.35	31.91

The observations were distributed as advantageously as possible in the different parts of the orbits; but the atmospheric and other conditions combined to prevent all observations of *Deimos* in that part of its orbit lying between position-angles 105° and 228°. In general, micrometer observations were not made when the seeing was sufficiently good to permit study of the features of the surface of the planet.

After reducing my observations of *Phobos* up to and including Nov. 9, which covered six elongations, I noticed that the eastern elongation-distance was nearly 1″ greater than the western. An examination of Professor HALL's 1877 observations showed that the western elongation-distance was then about 2″.2 greater than the eastern. If the orbit had remained unchanged from 1877, the western distance in 1894 should have been about 1″.8 greater than the eastern. The change of nearly 2″.8 was evidence of a marked transformation of the orbit during the years 1877–1894. The line of apsides has probably revolved, owing to a polar compression of the planet. After November 9, I observed as many elongations as possible, and all confirm the change. By combining the observations made within a few minutes of the elongation-times, I obtained the excess or deficiency of the elongation-distances compared with MARTH's value of the semi-axis, as follows:

E. Elongation		W. Elongation	
	″		″
Oct. 25	+0.46	Oct. 27	−0.37
Nov. 2	+0.55	30	−0.62
9	+0.32	Nov. 2	−0.25
10	+0.42	10	−0.51
14	+0.41	13	−0.27
22	+0.45	14	−0.27
		14	−0.27
		22	−0.60

The complete reductions will change these figures a few hundredths of a second.

There are strong indications from the observations of *Deimos* that the orbit of that satellite has been similarly transformed; but the evidence is not so conclusive as in the case of *Phobos*, since the orbit of the latter is the more eccentric. From the observations made within a few minutes of the elongation-times, I obtained the excess or deficiency of the elongation-distances compared with MARTH's value of the semi-axis as below:

E. Elongation		W. Elongation	
	″		″
Oct. 12	+0.2	Oct. 11	−0.16
Nov. 7	+0.33	30	−0.13
		Nov. 13	−0.27
		14	+0.04

The complete reductions will change these figures slightly. The eastern elongation-distance appears to be about 0″.4 greater than the western. Professor HALL's 1877 observations made the western distance about 0″.8 greater than the eastern. There can be little doubt that the orbit has changed.

The orbit of *Phobos* is sufficiently eccentric to enable the direction of its major axis to be well determined. The motion of that axis furnishes a splendid method of investigating the polar compression of the planet.

Both satellites are 6ᵐ ± behind MARTH's ephemeris. Evidently the periodic times require some appreciable corrections.

After reducing the observations and briefly discussing them as above, I read with great interest Mr. WALTER S. HARSHMAN's paper on *The Orbit of Deimos* [*Astron. Jour.* no. 331], in which, from Professor HALL's 1892 observations, he finds an apparent motion of the pericenter of *Deimos*. I think the observations of 1894 will confirm in a general way the motion detected by Mr. HARSHMAN.

Mt. Hamilton, 1894 *Dec.* 31.

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MICROMETER-OBSERVATIONS OF THE SATELLITES OF MARS, BY PROF. W. W. CAMPBELL.

PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed February 9.*

THE

ASTRONOMICAL JOURNAL.

No. 338.

VOL. XV. BOSTON, 1895 FEBRUARY 28. NO. 2

OBSERVATIONS OF COMET *e* 1894, (*SWIFT*),*

By E. E. BARNARD.

At the urgent request of Drs. GOULD and CHANDLER, I have made a desperate effort to get some measures of SWIFT'S comet.

The unfortunate weather that has prevailed at Mt. Hamilton for the past two months had completely prevented any observations of this object since Nov. 30. On Jan. 24, the first opportunity to try for the comet, I made careful search in the ephemeris place with the 12-inch, but without success. The following night, Jan. 25, I tried for it with the 36-inch. The comet was found with the greatest difficulty. It was most excessively faint and difficult, about 10″ to 15″ in diameter. From the very small field of the 36-inch, it was not possible to reach any known star; I therefore compared it with a 16^M star in the same field, and this star in turn was referred to a known star.

Though extremely difficult to see and measure, it is, from its small size, an object that can be measured with much accuracy,—indeed with as much accuracy as the brightest comet devoid of a nucleus.

The comet has been followed from night to night with the greatest difficulty until the moon has cut off further observations.

I do not think it will be possible to see this object again, and the question of identity with DEVICO'S comet must rest with these observations. Through the kindness of Prof. SCHAEBERLE, I have been able to observe the comet on his nights, as well as on my own, with the 36-inch. The measures have been made with the greatest possible care, and I think will be found to be very close to the true places of the comet, notwithstanding the extreme difficulty of seeing and measuring it.

The difference of right-ascension has been measured directly on each night.

Jan. 25	$\Delta\alpha$ (☄ — ∗) =	$+\ 97''.04$
26		$+\ 34.99$
27		-227.74
28		$+\ 71.28$
29		-172.38

The following are the measures of the comparison-stars.

Jan. 25. Star 16^M—star $8^M.2$ (DM. 7°197)

$\Delta\alpha = -1^m\ 4^s.35$; $\Delta\delta = +2'\ 19''.4$ (3 comp.)

I also referred this 16^M star to a 12^M by direct measures.

$(16^M - 12^M)$ $\Delta\alpha = +2'\ 35''.9 = +0^m\ 10^s.49$;

$\Delta\delta = +0'\ 36''.5$ (4 comp.)

The 12^M star was also referred to the $8^M.2$ DM. star.

$(12^M - 8^M.2)$ $\Delta\alpha = -1^m\ 14^s.87$;

$\Delta\delta = +1'\ 44''.7$ (4 comp.)

The adopted place of the 16^M comparison-star is the mean of the two determinations above.

Jan. 26. 12^M comp.-star $-8^M.3$ (DM. 7°203).

$\Delta\alpha = -2^m\ 3^s.04$ (5 transits) ; $\Delta\delta = +1'\ 17''.9$ (4 obs.)

Jan. 27. 13^M comp.-star $9^M.5$ (DM. 8°220).

$\Delta\alpha = -0^m\ 8^s.05$ (4 obs.) ; $\Delta\delta = -6'\ 50''.8$ (3 obs.)

Jan. 29. 12^M comp.-star $-9^M.0$ (DM. 8°231).

$\Delta\alpha = +1^m\ 40^s.81$ (4 transits) ; $\Delta\delta = -1'\ 41''.3$ (3 obs.)

The stars with which I have compared the small comparison-stars have the following positions for 1895.0.

	α	δ	Authority
	h m s	° ′ ″	
Jan. 25	1 13 59.12	+7 50 35.2	Kam A.N. Catal. (Berlin and Hamb.)
26	17 22.63	+8 11 17.8	W. Bessel I, 238
27	18 4.2	+8 31.3	DM. 8°220
29	1 20 57.64	+8 59 4.5	W. Bessel I, 310

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* Positions printed in Supplement to No. 337.

FILAR-MICROMETER OBSERVATIONS OF COMET *e* 1894 (*SWIFT*).*

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY E. E. BARNARD.

1895 Mt. Hamilton M.T.		$*$	No. Comp.	☄ — $*$ $\Delta\alpha$	☄ — $*$ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Jan. 25	7 41 15	1	3 , 6	+0 6.53	+4 55.9	1 13 1.17	+7 54 54.0	9.502	0.659
26	7 28 3	2	6 , 6	+0 2.36	−2 11.8	15 21.94	+8 10 27.3	9.483	0.653
27	7 16 12	3	5 , 6	−0 15.35	+1 9.7	17 57.0	+8 25.7	9.445	0.648
28	7 34 10	4	4	+0 4.81	. . .	20 6.38	. . .	9.510	. . .
	7 48 38	4	7	. . .	−3 23.4	. . .	+8 42 4.3	. . .	0.646
29	7 35 48	5	4 , 6	−0 11.63	+0 50.8	1 22 26.80	+8 57 17.6	9.512	0.647

Mean Places for 1895.0 of Comparison-Stars.

$*$	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 12 54.75	−0.11	+7 52 55.5	+2.6	Anon. 16ᴹ
2	15 19.59	−0.01	+8 12 35.7	+3.4	Anon. 12ᴹ
3	18 12.3	−0.02	+8 24.5	+3.4	Anon. 13ᴹ
4	20 1.60	−0.03	+8 45 24.2	+3.5	Weisse-Bessel 1, 291
5	1 22 38.45	−0.02	+8 56 23.2	+3.6	Anon. 12ᴹ

The estimated magnitudes are only approximate.

IMPROVED ELEMENTS OF COMET *e* 1894.*

BY S. C. CHANDLER.

The receipt, on Feb. 7, of the four observations so fortunately obtained by Prof. BARNARD near the end of January, has induced me to correct the orbit given in *A.J.* 333, by uniting all the available positions (27) into six normal places, and forming differential equations for the variation of all six elements. If Prof. BARNARD is right in thinking that the comet cannot again be seen, the following elements will be very close to the definitive values for this apparition.

ELEMENTS.

$$T = 1894 \text{ Oct. } 12.18817 \pm 0^{d}.05870 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \omega &= 296^{\circ}\ 31'\ 35''.2 && \pm 140''.0 \\ \Omega &= 18\ 44\ 37.1 && \pm\ 71.0 \\ i &= 2\ 57\ 53.9 && \pm\ 2.9 \end{aligned}\right\} 1894.0$$

$$\log q = 0.4436451 \qquad \pm 0.0001310$$

$$e = 0.571895 \qquad \pm 0.001000$$

Period = 5.8633 years = 2141.6 days

Cambridge, 1895 *Feb.* 9.

COORDINATES FOR THE EQUATOR.

$$\left.\begin{aligned} x &= [9.9996714]\, r \sin(\ 75^{\circ}\ 16'\ 55''.3 + v) \\ y &= [9.9558901]\, r \sin(346\ 20\ 24.9 + v) \\ z &= [9.6339887]\, r \sin(340\ 36\ \ 8.3 + v) \end{aligned}\right\} 1894.0$$

$$\left.\begin{aligned} x &= [9.9996713]\, r \sin(\ 75\ 17\ 45.6 + v) \\ y &= [9.9558922]\, r \sin(346\ 21\ 15.8 + v) \\ z &= [9.6339810]\, r \sin(340\ 36\ 54.6 + v) \end{aligned}\right\} 1895.0$$

REPRESENTATION OF NORMAL PLACES, (O—C).

Gr. M.T.	$\Delta\alpha$	$\Delta\delta$	No. Obs.
	s	″	
1894 Nov. 23.5	+0.20	−2.8	4
30.5	−0.38	−1.2	5
Dec. 16.5	−0.16	+5.7	4
20.5	+0.11	+4.5	5
29.5	+0.16	−4.1	5
1895 Jan. 27.5	+0.15	−0.7	4

EPHEMERIS FROM THE PRECEDING ELEMENTS.*

BY GEORGE E. WHITAKER.

Gr. M.T.	App α	App δ	log Δ	Br.	Gr. M.T.	App α	App δ	log Δ	Br.
1895	h m s	° ′ ″			1895	h m s	° ′ ″		
Feb. 6.5	1 40 15.39	+10 54 2.4	0.29213	0.160	Feb. 10.5	1 49 56.98	+11 50 19.3	0.30533	0.146
7.5	43 3.73	+11 8 18.5			11.5	52 14.17	+12 4 3.8		
8.5	45 21.77	+11 22 26.7			12.5	54 31.08	+12 17 10.2		
9.5	1 47 39.52	+11 36 27.0			13.5	1 56 47.72	+12 31 8.8		

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* From Supplement to No 337. The R.A. on Jan. 29 has been changed at Prof. BARNARD's request.

Gr. M.T.	App. α	App. δ	log Δ	Br.
1895	h m s	° ′ ″		
Feb. 14.5	1 59 4.09	+12 44 29.6	0.31827	0.131
15.5	2 1 20.21	+12 57 42.6		
16.5	3 36.08	+13 10 47.7		
17.5	5 51.70	+13 23 45.1		
18.5	8 7.08	+13 36 34.6	0.33091	0.123
19.5	10 22.22	+13 49 16.4		
20.5	12 37.13	+14 1 50.4		
21.5	14 51.81	+14 14 16.6		
22.5	17 6.27	+14 26 35.1	0.34333	0.113
23.5	19 20.52	+14 38 45.8		
24.5	21 34.55	+14 50 48.8		
25.5	23 48.37	+15 2 44.1		
26.5	2 26 1.98	+15 14 31.7	0.35543	0.104
Feb. 27.5	2 28 15.37	+15 26 11.5		
28.5	30 28.55	+15 37 43.6		
Mar. 1.5	32 41.52	+15 49 8.0		
2.5	34 51.29	+16 0 24.7	0.36724	0.095
3.5	37 6.84	+16 11 33.7		
4.5	39 19.20	+16 22 34.9		
5.5	41 31.35	+16 33 28.5		
6.5	43 43.28	+16 44 14.4	0.37874	0.088
7.5	45 55.01	+16 54 52.7		
8.5	48 6.53	+17 5 23.3		
9.5	50 17.84	+17 15 46.2		
Mar. 10.5	2 52 28.95	+17 26 1.5	0.38991	0.082

OBSERVATIONS OF VARIABLE STARS,

By EDWIN F. SAWYER.

100. *T Ceti.*

Observed from 1891 October 25 to December 28, eight observations. The light remained nearly constant during the two months the star was under observation. On October 25, *T* was = 28 (*U.A.*) *Ceti*, and 3 steps > 21 (*U.A.*) *Ceti*, or $6^{M}.6$. On November 2 the light had apparently increased about 2 steps, where it remained until the observations ended. The star was again observed 1892 August 29, and found to be = 10 (*U.A.*) *Ceti*, and 3 steps > 28 (*U.A.*) *Ceti*, or about $6^{M}.3$. The light remained apparently constant until December 9, when a slight decrease, 3 steps, occurred, and no further change was recorded up to the time the observations terminated, 1893 January 8. The observations number 12.

893. *U Ceti.*

This star was observed on ten evenings, from 1891 December 18 to 1892 February 18. Observations near maximum much interrupted by cloudy weather and the moonlight. When first seen, on December 18, *U* was 5 steps > SDM. 13°483, and 2 steps < SDM. 13°502, or $8^{M}.3$. The light increased quite rapidly, and a maximum was passed about 1892 January 23, the maximum brightness being 3 or 4 steps < SDM. 12°481, and 3 steps > SDM. 13°457, or $6^{M}.95$. When last seen, on February 18, *U* was 2 or 3 steps < SDM. 13°457, and 3 steps > SDM. 13°492, or $7^{M}.2$. The star was again observed, 1893 November 29, and found to be = SDM. 13°502, and 5 steps < SDM. 13°492, or $8^{M}.0$. The light increased quite rapidly and uniformly, and a maximum was reached December 25, the maximum brightness being 2 steps < SDM. 13°457, and 5 steps > SDM. 13°492, or $7^{M}.0$. The observations ended 1894 January 28. *U* being 3 steps < SDM. 13°502, or about $8^{M}.4$. The observations number 17. From all my observed maxima since 1886 the mean period is found to be 235.1 days, which agrees very closely with the period 235.8 days given in Dr. CHANDLER'S Catalogue.

1072. *ρ Persei.*

Observed from 1891 September 2 to 1892 March 29, the observations numbering 19. On September 2, *ρ* was found quite faint, evidently near a minimum. The light slowly increased, and on October 8 it had about reached its normal brightness, where it remained, with the exception of one or two slight minor fluctuations, until the observations ended. When observations were again resumed, on August 15, *ρ* was found to be quite faint. A slow increase of light occurred, and by September 17, it had reached its normal brightness, where it remained until observations ceased, 1893 April 2. The observations number 20. On September 6 the star was again seen, and found to be rather faint. Observations on the 10th and 12th found it still fainter, a minimum being fairly well indicated. The light slowly increased after the 16th, and with the exception of a slight depression, from 1894 January 22 to February 11, no further changes occurred until the observations ended on April 2. There were 33 observations.

1768. *ε Aurigae.*

This star has been under observation at various times, namely, from 1892 September 11 to 1893 January 9, nine observations, and from October 5 to 1894 April 2, 26 observations. The fluctuations of light during these times have been hardly noticeable, certainly not over two or three steps, and no decided phases have been determined.

1771. *R Leporis.*

This star was observed on ten evenings, from 1892 November 16 to 1893 January 6. *R* was evidently near a maximum when the observations commenced, as the light remained apparently constant from November 16 to December 22, or 36 days. The star was again observed 1893 November 16, and found to be quite bright, and = SDM. 15°903, and 4 steps < SDM. 15°910, or $7^{M}.9$. The light increased quite slowly, and a maximum was passed 1894 January 20, the maximum brightness being 2 steps > SDM.

15°910, and 3 or 4 steps < SDM. 14°1029, or $7^{\mathrm{M}}.4$. The light remained apparently constant 42 days, or from January 1 to February 11. The decrease was very slow, and when last seen, on March 26, *R* was 3 steps > SDM. 15°903, and 3 steps < SDM. 15°910, or $7^{\mathrm{M}}.7$. The observations number 39.

2100. *U Orionis.*

This star was observed from 1891 December 28 to 1892 March 16, 20 observations. When first seen, on December 28, *U* was 3 steps > DM. 20°1168, and 3 steps < DM. 20°1171, or $8^{\mathrm{M}}.4$. The increase in light was quite rapid, and generally uniform, and a maximum was passed 1892 February 8, the maximum brightness being = DM. 20°1156, 4 steps > DM. 19°1106, and 5 steps < DM. 19°1110, or $6^{\mathrm{M}}.7$. When last observed *U* was = DM. 19°1106, and 5 steps < DM. 20°1156, or $7^{\mathrm{M}}.2$. The star was again observed 1893 January 8 and found to be = DM. 20°1168, or about $8^{\mathrm{M}}.6$. After a uniform and rapid increase, a maximum was reached 1893 February 11, the maximum brightness being 2 steps > DM. 19°1106, and 3 or 4 steps < DM. 20°1156, or $7^{\mathrm{M}}.0$. The decrease was quite slow, and when last seen, April 2, *U* was 3 steps > DM. 20°1168, and 4 steps < DM. 20°1171, or $8^{\mathrm{M}}.5$. The observations number 14.

2170. *S Leporis.*

This star 87 (*U.A.*) *Leporis* which I announced as variable in No. 263 of the *A.J.*, and included in the list of suspected variables in Dr. Chandler's second Catalogue, has since been confirmed by Mr. Yendell. The observations during 1892 and 1893 extend from December 11 to April 2, and number 12. The star was near a minimum when first seen on December 11. The light slowly increased, and a faint maximum was reached 1893 January 21. This was followed by a rapid fall, a minimum being fairly indicated about March 8. The star was again near maximum when the observations ended on April 2. The star was again observed 1893 November 28, and found to be quite bright. The light continued to increase, and a very bright maximum, the brightest yet observed, was passed 1894 January 15, the maximum brightness being 3 steps > 72 (*U.A.*) *Leporis* and 3 steps < 78 (*U.A.*) *Leporis*, or about $6^{\mathrm{M}}.5$. The light remained nearly constant from December 28 to February 5, or 39 days. After February 5 the light slowly faded, and the star was evidently near a minimum when the observations ended on March 26.

2266. *V Monocerotis.*

The star was observed on 15 evenings, from 1893 December 12 to 1894 February 5. After a rapid rise, a maximum was passed 1894 January 6. Comparison-stars not yet identified.

2676. *U Monocerotis.*

The observations on this star during 1891 and 1892 extend from October 31 to April 24. When charted they permit the determination of three maxima and two minima. The first maximum from a rapid rise was passed 1892 January 7, and it was a bright one. This was followed by a very rapid fall, and a rather faint minimum was reached January 30. A second and not very bright maximum was passed February 20. A second and very faint minimum was passed March 16, and a third maximum was reached April 3. The interval between the first and second maxima was 44 days, and between the second and third maxima 43 days. The interval between the two minima observed was 46 days. The observations during 1892 and 1893 number 41, and extend from December 9 to May 8. From these observations 3 maxima and 3 minima have been determined. The first minimum was passed 1892 December 16, and was rather faint. The first maximum was reached 1893 January 2. This was followed by a very bright minimum January 26. The second maximum was passed February 11, and the third April 8. All the maxima were very bright. The third minimum, a fairly bright one, was passed March 13. The interval between the first and second maxima was 40 days, and between the second and third maxima 56 days. The interval between the first and second minima was 41 days, and between the second and third minima 46 days.

3796. *U Hydrae.*

The observations on this star in 1893 were very scattering, and only number 6, extending from March 6 to May 18. When first observed, *U* was 3 steps > 236 (*U.A.*) *Hydrae*, and 2 or 3 steps < 225 (*U.A.*) *Hydrae*, or $6^{\mathrm{M}}.0$. On April 9, *U* was found to be 2 steps > 225 (*U.A.*) *Ceti*, or about $5^{\mathrm{M}}.6$. Observations on April 18 and May 8 found it apparently of the same brightness. On the date of the last observation, May 18, *U* had decreased about 3 steps, and was 1 step < 225 (*U.A.*) *Hydrae*, or $5^{\mathrm{M}}.9$. A maximum is indicated about April 24.

4940. *W Hydrae.*

Observed from 1892 March 5 to May 17, the observations numbering 10. *W* was about $7^{\mathrm{M}}.5$ when first seen. The light increased quite rapidly, and a very bright maximum was passed about April 20, the maximum brightness being 5 steps > 364 (*U.A.*) *Hydrae*, and 3 or 4 steps < 359 (*U.A.*) *Hydrae*, or $6^{\mathrm{M}}.6$. After April 26, the light slowly faded. In 1893 *W* was first detected February 17, and found to be = $8^{\mathrm{M}}.0$. On March 20 it was apparently of the same brightness. From this date the light increased very rapidly, and a bright maximum = $6^{\mathrm{M}}.6$ was passed about May 15. The observations number 9, and extend to June 18.

5912. *g Herculis.*

The observations on this star number 34, and extend from 1892 April 16 to October 21, but are somewhat scattering. When charted they permit the determination of only one maximum, a bright one, which was passed September 11. The observations in 1893 are 34 in number, and extend from April 18 to October 17. From these 3 maxima and 2 minima are well determined. The first and second maxima were passed May 19 and July 16, and were not very bright, the interval between the two being 58 days. The third maximum, a bright one, was reached September 2, or 48 days after the second maximum. The two minima were bright ones, and were passed June 19 and August 6, the interval being 48 days.

6733. *R Scuti.*

During 1892, 52 observations of this star were obtained, from May 16 to October 22. From these 4 maxima and 3 minima have been determined. The maxima were all of about the average brightness, and were passed June 1, July 15, September 7 and November 18, showing intervals of 44, 54 and 72 days respectively. The minima were also of about the average brightness; and were passed June 27, August 17 and October 10, showing intervals of 51 and 54 days respectively. The observations in 1893 number 58, and extend from May 11 to December 4. Serious breaks occur in the observations until after July 1. One maximum and two minima are quite well determined. The maximum of about average brightness was passed September 13, and the two minima were passed August 1 and October 22, showing an interval of 82 days.

6794. *R Lyrae.*

The following maxima and minima of this star have been determined since my last published list in 1889:

MAXIMA

Obs'd			Ep.	O−C d
1890	Aug.	2	27	+ 4.1
	Sept.	19	28	+ 5.4
	Dec.	10	30	− 5.2
1891	June	23	34	− 0.1
1892	Aug.	14	43	−16.0
	Sept.	26	44	−22.1
	Nov.	20	45	−15.9
1893	June	20	49	− 0.7
	Aug.	11	50	+ 2.1

MINIMA

Obs'd			Ep.	O−C d
1890	Aug.	31	28	+ 9.1
	Oct.	13	29	+ 5.4
1891	July	14	35	− 4.0
1892	Aug.	29	41	−27.4
	Dec.	23	46	− 9.1
1893	July	21	50	+ 3.8
	Sept.	3	51	− 1.4

In the column O−C a comparison is given with PANNEKOEK's elements published in *A.N.* No. 3252.

It will be noticed that while the residuals are small in the years 1890, 1891 and 1893, they are unusually large in the year 1892, and would appear to disapprove the results arrived at by the above astronomer. It is unfortunate that none of the other observers mentioned in his article, PLASSMANN, KNOPF, or YENDELL, have observations made at the same epochs in 1892 as were mine.

7120. *χ Cygni.*

A very good series of observations was secured on this star in 1892, extending from August 15 to November 19, and numbering 36. When first seen, August 16, χ was = DM. 32°3578, or about $8^M.2$. The increase was quite rapid and uniform, a maximum being passed September 17.5, the maximum brightness being 2 steps < DM. 33°3587 and 5+ steps > DM. 32°3531, or $5^M.5$. The decrease was also quite rapid, and when last observed, November 19, χ was 5+ steps < DM. 33°3602 and 5 steps > DM. 32°3578, or $7^M.6$.

7754. *W Cygni.*

After the faint minimum 1892 Aug. 12, *W* increased rather slowly, and a maximum of about the average brightness was passed October 19. The light faded very slowly and irregularly after October 21, and a bright minimum was passed about December 20. When the observations ended 1893 February 12, *W* was evidently near another maximum. May 11 the observations were resumed, *W* being found very faint. The light increased rather slowly, and a very bright maximum was reached July 9, the maximum brightness being 4 steps > DM. 46°3305 and = DM. 45°3558, or $5^M.5$, this being the brightest maximum yet observed. The light faded quite rapidly after July 14, and a very faint minimum was passed September 26. November 24 another maximum was passed. A second minimum was reached about 1894 January 25. The observations ended February 8, and number 89.

906. *R Trianguli.*

A very good series of observations on this star was obtained, extending from 1892 October 29 to 1893 January 16, and numbering 22. The light increased quite rapidly from October 29, a maximum being reached November 28, the maximum brightnesss being 2 or 3 steps > DM. 33°154, or about $6^M.2$. The other comparison-stars not yet identified. After December 5 the light faded quite rapidly.

Brighton, Mass., 1895 *Jan.* 12.

ON COMET *e* 1894 AND ITS IDENTITY WITH DeVICO'S, 1844 I.

BY S. C. CHANDLER.

The likeness of the orbit of SWIFT's Comet *e* 1894, to DeVico's, 1844 I, was generally remarked soon after its appearance. In particular SCHULHOF has presented considerations which make the hypothesis of indentity very plausible. In view, however, of the numerous close family resemblances among the periodic comets, we can distinguish between similarity or identity in the present case only by actual calculation of the principal planetary perturbations. Unfortunately the conditions under which the present comet has appeared make it difficult to determine, from the observations, the important element of the mean motion with enough precision for us to carry the perturbations very far backward with any confidence. Indeed it would be useless to attempt it, were it not for the skill and assiduity with which Wilson, Howe, and especially Barnard, have followed this extremely faint object to the extreme limits of the power of their telescopes, and thus provided the material for the reasonably satisfactory proof of the identity in question which is to be given below. Indeed this proof turns in effect — as does also the possible rediscovery of the the comet in 1900 — upon Howe's observation of Jan. 19, and the five by Barnard of Jan. 25–29; although it is still possible that the latter may have obtained some more recent measures, since the comet could be seen in February under conditions only slightly less favorable as to brightness, than it was in January.

To determine the perturbations suffered by the comet at its conjunction with *Jupiter* in 1884–6 it is necessary to find its elements with all the precision possible under the circumstances. I have therefore brought all the available observations to bear. The places of comparison-stars have been revised by a pretty thorough search of known catalogues. A comparison with my provisional orbit in *A.J.* 333 then furnished the following six normal places.

Greenwich M.T.	App. α h m s	App. δ ° ′ ″	Obs.
1894 Nov. 23.5	22 26 14.27	−12 11 49.8	4
30.5	22 46 11.90	− 9 47 5.1	5
Dec. 16.5	23 31 35.79	− 4 17 38.1	4
20.5	23 42 21.82	− 2 57 22.6	5
29.5	0 5 59.32	− 0 1 42.1	5
1895 Jan. 27.5	1 17 24.67	+ 8 21 6.5	4

From an approximate solution of the equations hereafter given, the following elements were then derived, to be corrected by the final solution.

$$T = 1894\ \text{Oct.}\ 12.1786\ \text{Gr.}$$

$$\left.\begin{array}{rl} \omega = & 296^\circ\,32'\,42''.5 \\ \Omega = & 48\ \ 45\ \ 53\ .1 \\ i = & 2\ \ 57\ \ 44\ .2 \end{array}\right\}\begin{array}{l}1894.0\\ \text{Eclip.}\end{array} \qquad \left.\begin{array}{rl} \omega' = & 340^\circ\,35'\,38''.0 \\ \Omega' = & 5\ \ 10\ \ 46\ .8 \\ i' = & 25\ \ 29\ \ 51\ .2 \end{array}\right\}\begin{array}{l}1894.0\\ \text{Eq.}\end{array}$$

$$\begin{array}{rl} \log q = & 0.113633 \\ e = & 0.572078 \end{array}$$

These were then compared with the normal places, and the differences referred to the plane of the comet's orbit, which was taken as the fundamental plane for the computation of the corrections to the assumed elements. These differences, so converted, form the absolute terms of the following equations of condition, where the differential coefficients were computed with elements differing unessentially from those above given.

$$\begin{array}{rrrrrrcr}
-2972\,\Delta T & +1.0343\,\Delta\chi' & +\ \ 3825\,\Delta q & +16660\,\Delta e & & & = & +3''.3 \\
-2851 & +1.0089 & -\ 19846 & +51870 & & & = & -4.8 \\
-2512 & +0.9556 & -\ 64320 & +59038 & & & = & -1.0 \\
-2161 & +0.9131 & -\ 73293 & +59758 & & & = & +2.3 \\
-2280 & +0.9163 & -\ 90617 & +59890 & & & = & +0.6 \\
-1713 & +0.8128 & -124505 & +50591 & & & = & -0.4
\end{array}$$

$$\begin{array}{rrrrrrcr}
-\ 20\,\Delta T & +0.0105\,\Delta\chi' & -\ 2622\,\Delta q & +\ \ \ 93\,\Delta e & -0.5904\,\Delta\Omega' & +0.2752\,\Delta i' & = & -6.2 \\
-\ 25 & +0.0142 & -\ 3715 & +\ \ \ 65 & -0.5566 & +0.3709 & = & +0.6 \\
-\ 26 & +0.0186 & -\ 5202 & -\ \ 266 & -0.4757 & +0.5398 & = & +7.6 \\
-\ 24 & +0.0187 & -\ 5310 & -\ \ 393 & -0.4556 & +0.5695 & = & +4.8 \\
-\ 20 & +0.0188 & -\ 5450 & -\ \ 680 & -0.4114 & +0.6340 & = & -2.2 \\
-\ \ \ 7 & +0.0145 & -\ 4303 & -1194 & -0.2850 & +0.7368 & = & -5.3
\end{array}$$

Giving equal weights, we have the normal equations in longitude,

$$\begin{array}{rrrrcr}
+37.7152\,\Delta T & -14.258\,\Delta\chi' & +\ 81.277\,\Delta q & -\ 80.840\,\Delta e & = & -\ 2''.64 \\
-14.258 & +\ 5.4399 & -\ 33.461 & +\ 31.087 & = & +\ 0.89 \\
+81.277 & -33.461 & +336.36 & -207.553 & = & +12.45 \\
-80.840 & +31.087 & -207.553 & +180.70 & = & -\ 0.57
\end{array}$$

where, for convenience, the unknowns are expressed in units of the third decimal for T and of the fourth decimal for q and e. The solution gives

$$\begin{array}{rcll}
\Delta T & = & +0.0957 & \pm 0.0587 \\
\Delta\chi' & = & +38''.0 & \pm\ 128''.0 \\
\Delta q & = & +0.000038 & \pm 0.000131 \\
\Delta e & = & -0.000183 & \pm 0.001000
\end{array}$$

Substituting these in the equations for latitude we form normal equations involving only the plane of the orbit.

$$\begin{array}{rrcr}
+1.3430\,\Delta\Omega' & -1.3546\,\Delta i' & = & -0''.92 \\
-1.3546 & +1.7700 & = & +1\ .84
\end{array}$$

whence $\Delta\Omega' = +9''.1\ \pm 4''.5 \qquad \Delta i' = +9''.7\ \pm 3''.9$

Applying these, and $\Delta\omega' = \Delta\chi' - \cos i'\ \Delta\Omega'$, to the above assumed elements for the equator, and referring back to the ecliptic, we have the corrected elements, with their probable errors, below. The latter are based on the adopted probable error for a single equation, ±2″.5, which is a mean between ±2″.0 and ±3″.1, obtained from the longitude and latitude-normals, respectively.

$$T = 1894\ \text{Oct.}\ 12.18817 \pm 0^{\text{d}}.05870\ \text{Gr.M.T.}$$

$$\begin{array}{rcll}
\omega & = & 296^\circ\,31'\,35''.2 & \pm 140''.0 \\
\Omega & = & 48\ \ 44\ \ 37.1 & \pm\ \ 71.0 \\
i & = & 2\ \ 57\ \ 53.9 & \pm\ \ \ \ 2.9
\end{array}\Bigg\}\ 1894.0$$

$$\begin{array}{rcll}
\log q & = & 0.1136451 & \pm 0.0001310 \\
e & = & 0.571895 & \pm 0.001000 \\
\text{Period} & = & 5.8633\ \text{years} & = 2141.6\ \text{days.}
\end{array}$$

These have already been published in the supplement issued with no. 337 and are reprinted elsewhere in this number. The comparison with the normal places is also there given, obtained by direct computation from the elements. It should be said that, after the solution was completed, an error of 3″ in the residual used for the fourth normal place was detected; but on examination it fortunately proved to be in a direction in which the normal place could itself be improved by an allowable rejection of a single discordant observation. Hence the solution was not repeated, as I think it is better as it now stands. Howe's observation of Jan. 19 arrived too late to be used in the computation of elements. Also, Barnard's right-ascension of Jan. 29, as originally communicated ($1^h\ 22^m\ 23^s.78$) was discordant by $-3^s.78$, and was rejected.*

Any refinement of the above elements, which an ultimate definitive calculation may give, will depend only on such nice considerations as the weighting of the observations, the propriety of rejection in one or two instances, the inclusion of a few for which star-places are wanting, and the perturbations during the appearance, which must be insignificant from the considerable distances of all the planets involved. The orbit may therefore be regarded as very close to a definitive one.

If the relations of the places of the comet during the conjunction with *Jupiter* in 1884–6, and their uncertainty as indicated by the probable errors of the elements defining its position near the aphelion-point, be considered, it will be seen that any great refinement in the computation of the perturbations for that approach would be labor thrown away, in this first approximation. I have therefore restricted it to the terms depending on the first power of the mass of the disturbing planet, judging that the effect of the higher powers of the disturbing force would be only of the order of those arising from the uncertainty of the elements. This first computation is necessarily of the nature of a reconnoissance merely. I therefore calculated the perturbations of the polar coordinates for about thirty-two months, from 1887 January back to 1884 May, at intervals of 20 days, while the distance was under 0.8 (1885 Sept. to 1884 Dec.), and of 40 days outside of those limits. The disturbance which took place outside of the distance 1.4 during the rapid approach in 1881, and outside of 1.6 at the slower recession in 1887, has therefore been neglected. Integrating for 1884 July 26 it was found that between that point and Jan. 1887 the place of perihelion had been moved forward by 1° 43′.3, the node retrograded by 11° 43′.2, the inclination increased by 0° 4′.8, and the mean daily motion decreased by 26″.7. The perturbation of the anomaly was −1° 31′.8. Both in direction and approximate amount these changes are uniformly of the character required to reconcile the differences between the observed orbits of the comets 1844 I, and *e* 1894. To make a direct comparison, I have applied these perturbations to the latter, and placed the resulting elements (osculating for 1884 July 26) in the second column below, headed "Before perturbation." Brünnow's elements of the comet of 1844 are given in the first column, and those of *e* 1894 in the third. All these elements are referred to the ecliptic and mean equinox of 1890.0.

	1844 I	*e* 1894	
	Observed	Before perturb.	Observed
T =	1882 Dec. 7.7	1883 Feb. 5.5	1894 Oct. 12.2
ω =	278° 48′.6	283° 7′.5	296° 34′.4
☊ =	64 20 .0	60 24 .0	18 10 .7
i =	2 54 .9	2 53 .1	2 57 .9
log q =	0.07423	0.09858	0.14364
e =	0.61765	0.60282	0.57190
log a =	0.49177	0.49959	0.51210
=	649″.15	631″.86	605″.15
Period =	5.466 years	5.615 years	5.863 years

It requires but a glance at this table to show that the hypothesis of identity is given a high degree of probability by the computation. The fact, that the calculated disturbances do not quite bridge the observed differences in the elements, strengthens the argument: since it is what we should expect from a general consideration of the character of the changes which I have omitted — namely, the neglected higher terms for the 1885 conjunction, and the perturbations of 1873–4, when another conjunction occurred. At the latter, although the distance of the comet throughout was greater than in 1884–86, the perturbations would have the same effect as regards direction, but be much smaller in amount. For the present the attempt to calculate these would be premature, whether by carrying my elements back, or bringing Brünnow's forward. It would be better to revise the mean motion, and with the improved value repeat the calculation, taking into account the minor disturbances here neglected. It is possible that more observations may yet come to hand. I consider the result of this paper to be sufficiently demonstrative of the high probability of identity to justify a more refined calculation at a proper future time. This will indeed be necessary before the next appearance, since a closer approach to *Jupiter* will occur previously, in 1897, with greater resultant changes in the elements than in 1885. These must be computed as rigorously as possible to justify any expectation that the comet can afterwards be found. However, I am inclined to anticipate that, with the present appearance, our acquaintance with this interesting body will unfortunately be brought to an end. The present perihelion distance will probably be changed by *Jupiter* in 1897 to one considerably beyond the orbit of *Mars*, so that unless a favorable reversion of the change in brilliancy which apparently took place between 1844 and 1894 should occur, it will in all likelihood hereafter be invisible; at least until, at some future approach to the critical point of disturbance near longitude 165°, simultaneously with *Jupiter*, it shall be thrown into a path in which, near perihelion, it will be again in reach of our telescopes.

Cambridge, 1895 *February* 22.

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* He has since corrected it. See p. 10. — Ed.

NOTE ON THE VISUAL MAGNITUDE OF THE FAINTEST STARS PHOTOGRAPHED BY DR. MAX WOLF, AT HEIDELBERG,

BY J. M. SCHAEBERLE.

Dr. MAX WOLF some time ago sent me an enlarged photograph of the region about *Algol*, for the purpose of determining the visual magnitude of the faintest stars visible on his plate, which had an exposure of five hours.

During his visit to the Lick Observatory in 1893, we spent a portion of an evening vainly trying to make a print of the stars photographed agree with the configurations visible in the telescope. On receiving his enlarged copy, the cause of our failure at once became apparent — the print we had used in 1893, was found to be a reversed one.

I recently compared the enlarged silver-print with the sky, and was quite surprised to find that it certainly contained the stars down to the 16.5 magnitude assuming that a 17.0 magnitude star is at the limit of vision of our 36-inch refractor.

As there is always some loss during the process of enlarging a photograph, it appears probable that practically every isolated star visible at Mt. Hamilton can be photographed by Dr. WOLF, at or near sea level, with his comparatively small telescope.

Lick Observatory, 1895 *February* 14.

OBSERVATIONS OF ENCKE'S COMET,

MADE AT GOODSELL OBSERVATORY, NORTHFIELD, MINN., WITH THE 16-INCH REFRACTOR AND FILAR MICROMETER,

BY H. C. WILSON.

[Communicated by Prof. W. W. PAYNE, Director of the Observatory.]

1894–95 Northfield M.T.		*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Dec. 28	7 10 17	1	6 , 4	+1 17.82	−6 22.1	22 14 49.59	+3 30 39.9	9.518	0.772
Jan. 16	6 49 51	2	9 , 6	−0 39.34	−0 19.4	21 59 43.33	−0 50 13.6	9.594	0.792
22	6 53 39	3	9 , 6	+0 1.88	−2 51.8	21 42 40.45	−4 30 50.4	9.620	0.795
23	6 11 48	1	12 , 6	−0 5.79	−6 12.0	21 38 47.79	−5 19 34.3	9.603	0.801

Mean Places for 1894.0 and 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 13 29.44	+2.33	+3 36 47.4	+14.6	Munich 30669
2	22 0 23.46	−0.79	−0 19 47.7	− 6.5	American Ephemeris
3	21 42 39.39	−0.82	−4 27 50.5	− 8.1	Schjellerup 8850
4	21 38 54.40	−0.80	−5 12 41.0	− 8.3	Yarnall 9756, Armagh$_2$ 2890

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed February 26.*

THE

ASTRONOMICAL JOURNAL.

No. 339.

VOL. XV. BOSTON, 1895 MARCH 12. NO. 3

OBSERVATIONS OF SMALL PLANETS,

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY LEWIS BOSS.

1894 Albany M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
			Hera (103).					
h m s			m s	′ ″	h m s	° ′ ″		
May 29 14 12 32	1	5	+0 20.88	−2 20.9	18 52 51.96	−16 49 17.3	n8.260	0.880
June 21 13 9 28	2	7	+1 35.54	−9 18.9	18 36 49.77	−17 19 46.1	8.831	0.848
28 12 50 45	3	7	+2 37.01	+1 17.3	18 30 31.92	−17 35 51.2	8.989	0.881
30 11 38 47	3	7	+0 50.16	−3 38.2	18 28 45.10	−17 40 46.5	n8.416	0.884
July 3 10 22 41	4	7	+4 15.69	+3 26.8	18 26 4.23	−17 48 30.5	n9.166	0.879
4 13 20 12	4	7 , 6	+3 14.66	+0 24.2	18 25 3.21	−17 51 33.1	9.317	0.873
5 11 30 43	4	6	+2 25.11	−2 7.8	18 24 13.67	−17 54 5.1	7.785	0.885
22 11 5 23	5	7	−0 42.00	+6 0.2	18 10 58.31	−18 44 18.3	9.060	0.885
Aug. 5 11 5 6	6	10 , 9	−1 20.35	−0 26.2	18 4 41.76	−19 27 55.7	9.360	0.875
6 9 21 15	6	8	−1 33.76	−3 19.2	18 4 28.34	−19 30 48.7	8.586	0.892
9 9 30 15	7	3	+4 12.12	+3 1.6	18 3 54.70	−19 40 6.0	8.910	0.891
10 11 9 57	7	6	+4 3.86	−0 15.9	18 3 46.43	−19 43 23.4	9.435	0.869
15 9 1 58	8	10	+0 25.00	+4 54.3	18 3 34.91	−19 58 16.4	8.862	0.892
16 9 5 7	8	9	+0 27.78	+1 55.2	18 3 37.68	−20 1 15.5	8.938	0.892
17 8 39 13	8	8	+0 32.40	−1 2.0	18 3 42.28	−20 4 12.7	8.630	0.894
			Chaldaea (313).					
June 28 11 26 33	9	5	+5 19.63	+0 27.3	19 6 59.00	− 5 3 20.1	n9.127	0.812
30 12 45 34	9	9 , 8	+3 23.08	−3 11.6	19 5 2.48	− 5 6 58.6	8.525	0.814
July 4 11 43 36	10	12	+0 57.83	−0 51.8	19 1 15.55	− 5 15 52.5	n8.676	0.812
5 10 29 46	10	9 , 6	+0 3.14	−3 22.3	19 0 20.87	− 5 18 22.9	n9.241	0.812
25 9 23 15	11	5	+3 31.84	−0 0.2	18 42 33.85	− 6 38 38.8	n9.083	0.827
26 11 21 40	12	6	+2 38.84	+0 31.1	18 41 44.59	− 6 44 11.9	9.049	0.824
Aug. 5 12 43 54	13	8	+3 1.21	+4 12.9	18 35 18.19	− 7 39 53.6	9.505	0.813
9 11 15 7	14	6	−1 37.95	+1 16.7	18 33 24.33	− 8 2 59.6	9.318	0.827
			Andromache (175)					
July 27 13 32 34	15	8	−0 39.70	−6 45.6	22 37 49.62	−13 20 59.4	n8.907	0.862
Aug. 5 14 4 17	16	8	+1 1.20	−4 13.6	22 33 20.92	−13 48 43.4	8.768	0.865
6 13 56 26	17	8	+0 26.95	+2 52.6	22 32 45.49	−13 52 3.5	8.718	0.866
9 13 28 14	18	5	+4 20.08	+5 41.4	22 30 53.66	−14 2 26.9	8.378	0.867
10 13 10 17	18	7	+3 41.19	+2 12.5	22 30 14.79	−14 5 55.8	n7.370	0.868
22 10 45 29	19	7	+3 31.97	+2 10.2	22 21 37.83	−14 48 25.2	n9.238	0.864
26 12 56 57	20	5	+2 33.69	−2 57.3	22 18 28.98	−15 2 7.5	9.068	0.869
			Laurentia (162).					
Sept. 29 14 4 59	21	8	−0 35.66	+4 59.9	0 25 43.38	− 2 17 19.2	9.384	0.833

Mean Places for 1894.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	18 52 28.61	+2.44	−16 46 43.5	−12.9	Albany, 2 observations
2	18 35 11.25	+2.98	−17 10 21.1	− 6.1	Albany, 2 observations
3	18 27 51.85	+3.06 +3.09	−17 37 2.4	− 6.4 − 6.2	Yarn.8018, *A.N.*82-14, Albany 2 obs.(Note 1)
4	18 21 45.39	+3.15 +3.17	−17 51 50.7	− 6.6 − 6.6	Yarn. 7965, Gould 25182, Albany 2 obs.
5	18 11 37.08	+3.23	−18 50 11.3	− 7.2	Yarn. 7890, Gould 24927, Albany 2 obs.
6	18 5 58.91	+3.20 +3.19	−19 27 21.8	− 7.7 − 7.7	Albany, 3 observations
7	17 59 39.44	+3.14 +3.13	−19 42 59.4	− 8.2 − 8.1	Albany, 2 observations
8	18 3 6.78	+3.13 +3.10	−20 3 2.6	− 8.1	Albany, 2 observations
9	19 1 36.53	+2.84 +2.87	− 5 3 42.9	− 4.5 − 4.1	Gould 26181, Albany 3 obs. (Note 2)
10	19 0 14.77	+2.95 +2.96	− 5 14 56.9	− 3.8 − 3.7	Albany, 2 observations
11	18 38 58.95	+3.06	− 6 38 35.3	− 3.3	Albany, 2 observations
12	18 39 2.68	+3.07	− 6 44 39.8	− 3.2	Albany, 2 observations
13	18 32 13.92	+3.06	− 7 44 3.2	− 3.3	Albany, 2 observations (Note 3)
14	18 34 59.22	+3.06	− 8 4 13.4	− 2.9	Albany, 2 observations
15	22 38 26.29	+3.03	−13 14 28.7	+14.9	Munich I and Munich II
16	22 32 16.46	+3.26	−13 44 45.1	+15.3	Munich I and Munich II
17	22 32 15.27	+3.27	−13 55 11.4	+15.3	Bonn VI and Munich I
18	22 26 30.24	+3.34 +3.36	−14 8 23.5	+15.2	Bonn VI and Gould 30728
19	22 18 2.33	+3.53	−14 50 50.4	+15.0	Munich I and Munich II
20	22 15 51.70	+3.59	−14 59 25.2	+15.0	Rümker 10111 and Munich I
21	0 26 15.51	+3.53	− 2 22 42.9	+23.8	Gould 441 and Karlsruhe

(1) ∗ 3, adopted proper motion (LALANDE and ARGELANDER), 0s.000, −0″.10. (2) ∗ 9, adopted proper motion (LALANDE, BESSEL, LAMONT), +0s.007, −0″.03. (3) ∗ 13, a proper motion of 0″.1 in position-angle 180° is probable.

In the reduction of the foregoing observations, one turn of the micrometer-screw was assumed to measure 22″.867. This value rests on nine series of determinations upon nine different nights, 1894 June 14 to 1895 January 23.

It is proposed to adhere to the use of this value until some material change may be indicated as necessary. Thus far, I have been unable to discover any measurable irregularity in the successive turns of this screw, though the arrangement of the reticule is favorable for the investigation of this point. The results may be summarized thus:

Method	Result	Wt.
	″	
Transits,	22.865	2
$\Delta\delta$, γ to δ *Ceti.*	22.873	2
$\Delta\delta$, small arcs $>30'$	22.856	1
Concluded value,	22″.867 ± 0″.003	

EPHEMERIS OF VARIABLES OF THE *ALGOL*-TYPE,

BY P. S. YENDELL.

The following Ephemeris is in continuation of CHANDLER'S, interrupted some months since, and is made up and will be continued in the same manner.

The times for 6142 *Z Herculis* are the odd epochs, taken direct from HARTWIG'S Ephemeris; the even ones for the coming season are not given, as they will occur in the daytime both here and in Europe. Inasmuch as some uncertainty seems yet to remain as to the subdivision of the four-day period, observations to prove or disprove the existence of these odd minima are very important.

APPROXIMATE EPHEMERIS OF MINIMA, 1895 GREENWICH M.T.

	March			March			April			April			April	
	d	h		d	h		d	h		d	h		d	h
δ Librae	1	8	*U* Cephei	16	22	*U* Coronae	1	8	*S* Antliae	15	16	*U* Cephei	30	19
U Ophiuchi	1	15	*U* Ophiuchi	17	14	*U* Ophiuchi	1	16	*U* Cephei	15	20	δ Librae	30	21
S Cancri	1	17	*S* Antliae	17	14	*S* Antliae	1	19	*Z* Herculis	15	20			
S Antliae	1	19	δ Librae	17	15	*Y* Cygni	1	21	*Y* Cygni	16	21		May	
U Cephei	1	23	*R* Canis Maj.	18	8	*U* Ophiuchi	2	12	*S* Antliae	16	15	*Z* Herculis	1	19
Algol	2	5	*U* Ophiuchi	18	10	*S* Antliae	2	18	*U* Ophiuchi	16	16	*U* Ophiuchi	1	21
R Canis Maj.	2	11	*U* Coronae	18	13	Algol	2	18	*S* Antliae	17	14	*Y* Cygni	1	21
U Ophiuchi	2	12	*S* Antliae	18	14	δ Librae	2	22	*U* Ophiuchi	17	15	*U* Coronae	2	10
S Antliae	2	18	*U* Ophiuchi	19	6	*U* Ophiuchi	3	8	*U* Cephei	18	8	*U* Ophiuchi	2	17
R Canis Maj.	3	14	*U* Cephei	19	10	*U* Cephei	3	9	*U* Ophiuchi	18	11	*U* Cephei	3	7
S Antliae	3	18	Algol	19	10	*R* Canis Maj.	3	10	*U* Coronae	18	14	*U* Ophiuchi	3	13
δ Librae	3	17	*R* Canis Maj.	19	12	*S* Antliae	3	18	*S* Antliae	18	14	*U* Ophiuchi	4	9
U Ophiuchi	3	7	*S* Antliae	19	13	*Z* Herculis	3	20	δ Librae	19	6	*Y* Cygni	4	20
U Cephei	4	11	λ Tauri	19	19	*Y* Cygni	4	21	*R* Canis Maj.	19	9	δ Librae	5	13
U Coronae	4	17	*S* Antliae	20	12	*R* Canis Maj.	4	13	*S* Antliae	19	13	*U* Cephei	5	19
R Canis Maj.	4	17	*R* Canis Maj.	20	15	*S* Antliae	4	17	*Z* Herculis	19	20	*Z* Herculis	5	19
S Antliae	4	17	*S* Cancri	20	17	*U* Coronae	4	19	*Y* Cygni	19	21	*U* Coronae	5	21
S Antliae	5	16	*S* Antliae	21	12	Algol	5	15	Algol	19	22	*U* Ophiuchi	6	22
U Ophiuchi	5	20	*R* Canis Maj.	21	18	*R* Canis Maj.	5	16	*R* Canis Maj.	20	12	*U* Ophiuchi	7	18
R Canis Maj.	5	21	*U* Ophiuchi	21	19	*S* Antliae	5	16	*S* Antliae	20	13	δ Librae	7	20
S Antliae	6	16	*S* Antliae	21	19	*U* Cephei	5	21	*U* Cephei	20	20	*Y* Cygni	7	20
U Ophiuchi	6	16	*U* Cephei	21	22	*U* Ophiuchi	5	21	*S* Antliae	21	12	*U* Cephei	8	7
R Canis Maj.	6	16	Algol	22	7	*S* Antliae	6	16	δ Librae	21	13	*U* Ophiuchi	8	14
U Cephei	6	23	δ Librae	22	7	*U* Ophiuchi	6	17	*R* Canis Maj.	21	15	*U* Coronae	9	8
U Ophiuchi	7	13	*U* Ophiuchi	22	15	*Y* Cygni	6	21	*U* Ophiuchi	21	19	*U* Ophiuchi	9	10
S Antliae	7	15	*S* Antliae	22	19	*R* Canis Maj.	6	21	*S* Antliae	21	20	*Z* Herculis	9	19
λ Tauri	7	22	*R* Canis Maj.	22	21	*U* Ophiuchi	7	13	*U* Ophiuchi	22	15	δ Librae	9	22
Algol	7	22	*U* Ophiuchi	23	12	δ Librae	7	14	Algol	22	19	*U* Ophiuchi	10	6
δ Librae	8	8	*S* Antliae	23	17	*S* Antliae	7	15	*R* Canis Maj.	22	18	*U* Cephei	10	19
U Ophiuchi	8	9	λ Tauri	23	18	*Z* Herculis	7	20	*S* Antliae	22	19	*Y* Cygni	10	20
S Antliae	8	14	*U* Ophiuchi	24	7	*U* Coronae	8	6	*Y* Cygni	22	21	δ Librae	12	12
S Cancri	8	16	*U* Cephei	24	10	*U* Cephei	8	9	*U* Cephei	23	8	*U* Coronae	12	18
R Canis Maj.	9	6	δ Librae	24	15	*U* Ophiuchi	8	9	*U* Ophiuchi	23	12	*U* Ophiuchi	12	18
U Cephei	9	11	*S* Antliae	24	17	Algol	8	11	*S* Antliae	23	18	*U* Cephei	13	6
S Antliae	9	14	*U* Coronae	25	12	*S* Antliae	8	14	*Z* Herculis	23	19	*U* Ophiuchi	13	15
R Canis Maj.	10	9	*S* Antliae	25	16	*S* Cancri	8	16	δ Librae	23	21	*Z* Herculis	13	18
S Antliae	10	13	*R* Canis Maj.	26	7	δ Antliae	9	14	*S* Antliae	24	17	*Y* Cygni	13	20
δ Librae	10	16	*U* Coronae	26	14	*S* Librae	9	22	*U* Coronae	25	12	*U* Ophiuchi	14	11
Algol	10	19	*S* Antliae	26	15	*Y* Cygni	10	21	Algol	25	16	δ Librae	14	20
S Cancri	11	5	*U* Ophiuchi	26	19	*R* Canis Maj.	10	7	*S* Antliae	25	16	*U* Ophiuchi	15	7
S Antliae	11	12	*U* Cephei	26	22	*U* Cephei	10	10	*U* Cephei	25	20	*U* Cephei	15	18
R Canis Maj.	11	13	*R* Canis Maj.	27	10	*S* Antliae	10	11	*Y* Cygni	25	21	*S* Cancri	16	14
U Coronae	11	15	*S* Antliae	27	14	*S* Antliae	10	19	*S* Antliae	26	15	*Y* Cygni	16	20
U Ophiuchi	11	17	λ Tauri	27	17	*U* Ophiuchi	10	22	*U* Ophiuchi	26	20	*Z* Herculis	17	18
S Antliae	11	19	*U* Ophiuchi	27	17	Algol	11	8	*R* Canis Maj.	27	7	*U* Ophiuchi	17	19
λ Tauri	11	21	*U* Ophiuchi	28	12	*S* Antliae	11	10	*S* Antliae	27	15	*U* Cephei	18	6
U Cephei	11	22	*S* Antliae	28	12	*U* Coronae	11	17	*S* Cancri	27	15	*U* Ophiuchi	18	15
U Ophiuchi	12	13	*R* Canis Maj.	28	14	*S* Antliae	11	18	*U* Ophiuchi	27	16	*U* Ophiuchi	19	11
R Canis Maj.	12	16	*U* Coronae	28	21	*U* Ophiuchi	11	18	*Z* Herculis	27	19	δ Librae	19	12
S Antliae	12	19	δ Librae	29	7	*Z* Herculis	11	20	*R* Canis Maj.	28	10	*U* Coronae	19	16
U Ophiuchi	13	9	*U* Ophiuchi	29	8	*R* Canis Maj.	11	10	*U* Ophiuchi	28	12	*Y* Cygni[*]	19	20
Algol	13	16	*U* Cephei	29	9	*R* Canis Maj.	12	13	Algol	28	13	*U* Ophiuchi	20	8
S Antliae	13	18	*S* Antliae	29	11	*U* Ophiuchi	12	14	δ Librae	28	13	*U* Cephei	20	18
R Canis Maj.	13	19	*R* Canis Maj.	29	17	*S* Antliae	12	18	*S* Antliae	28	14	*Z* Herculis	21	18
S Antliae	14	17	*S* Antliae	30	18	*U* Ophiuchi	13	10	*Y* Cygni	28	21	δ Librae	21	20
δ Librae	15	8	*R* Canis Maj.	30	20	*R* Canis Maj.	13	16	*U* Cephei	28	7	*U* Ophiuchi	22	20
S Antliae	15	17	Algol	30	21	*S* Antliae	13	17	*U* Ophiuchi	29	8	*Y* Cygni	22	20
λ Tauri	15	20	δ Librae	31	15	*Y* Cygni	13	21	*R* Canis Maj.	29	13	*U* Cephei	23	6
Algol	16	13	λ Tauri	31	16	δ Librae	14	14	*S* Antliae	29	13	*U* Ophiuchi	23	16
S Antliae	16	15	*S* Antliae	31	18	*R* Canis Maj.	14	20	*S* Antliae	30	13	*U* Ophiuchi	24	12
U Ophiuchi	16	19	*U* Cephei	31	21	*S* Antliae	14	16	*R* Canis Maj.	30	16	*U* Ophiuchi	25	8

	May d	h		May d	h		May d	h		May d	h		May d	h
U Cephei	25	18	δ Librae	26	11	*U* Cephei	28	5	*Y* Cygni	28	20	*U* Cephei	30	17
Z Herculis	25	18	*U* Coronae	26	14	δ Librae	28	19	*U* Ophiuchi	29	13	*Y* Cygni	31	20
Y Cygni	25	20	*U* Ophiuchi	27	21	*U* Ophiuchi	28	17	*Z* Herculis	29	18			

NOTES ON VARIABLE STARS. — No. 7.

By HENRY M. PARKHURST.

In December, 1894, I invented and constructed a Recording Photometer, with which the position of the point of extinction is obtained by measurement. One end of a sliding rod carries a pointer, or small ring, in the field of the telescope, while the other end carries a pencil to record the position upon a sheet of paper carried between rollers. This method may be less accurate, but is more expeditious, especially in the observation of polar stars, for which alone it was intended.

Results of Observations.

No.	Star	Phase	Observed Date Julian	Observed Date Calendar	E	Corr.	W	Remarks
6849	*R Aquilae*	Max.	3013	1894 July 3	41	+27	6	Traces of secondary maximum
"	"	Min.	3165	Dec. 2	42	0	0	Elements; evidently later, but lost in the west
6894	*S Lyrae*	Max.	3086	Sept. 14	–	–	6	Remains visible about seven months
6900	*W Aquilae*	Max.	3121.2	Oct. 19	–	–	9	Changes at maximum slow
6903	*T Sagittarii*	Min.	3134	Nov. 1	27	–	1	Perhaps much later; previous maximum may have been much delayed
6905	*R Sagittarii*	Max.	3007	June 27	38	–22	9	Corresponds with maximum B of last year
"	"	Min.	3119	Oct. 17	39	–16	2	
(6915)	*— Sagittarii*	Max.	3120	Oct. 18	–	–	1	Apparently rapid fluctuation; I do not yet vouch for its variability
6921	*S Sagittarii*	Max.	3006	June 26	44	–10	6	Correction the same as last year
6923	*Z Sagittarii*	Max.	3120.6	Oct. 18	5	+11	9	Revised elements, *A.J.* 319
–	*— Aquilae*	–	–	–	–	–	–	DM. +12°4027; no period will satisfy observations
7085	*RT Cygni*	Max.	2996.6	June 16	13	+13	5	Revised elements, *A.J.* 319
"	"	Min.	3103.0	Oct. 1	14	+30	9	" " "
"	"	Max.	3185.8	Dec. 22	14	+13	9	" " "
7118	*X Aquilae*	Max.	3043	Aug. 2	–	–	6	*A.J.* 323
7192	*Z Cygni*	Max.	2991	June 11	10	– 1	5	Fell below 13 mag. in < 90 days
7234	*R Capricorni*	Max.	3135	Nov. 2	37	–21	5	Confirms correction of last year
7252	*W Capricorni*	Max.	3097	Sept. 25	39	+12	7	Compared as before with elements in *A.J.* 319
7259	*RS Cygni*	–	–	–	–	–	–	No possible period will satisfy the obs.
7261	*R Delphini*	Max.	3030	July 20	37	– 8	4	
"	"	Min.	3074	Dec. 11	38	–	0	Assumed minimum, invisible at least 30 days
7455	*U Capricorni*	Max.	3119	Oct. 17	67	–22	7	Agrees with result last year
7458	*V Delphini*	–	–	–	–	–	–	Period possibly 542 days
7468	*T Aquarii*	Max.	3076	Sept. 4	59	–14	5	No indications of a later crest; *A.J.* 311
7571	*V Capricorni*	Max.	3103.9	Oct. 1	63	+10	9	Seems to fluctuate near maximum.
7659	*T Capricorni*	Max.	3150.3	Nov. 17	53	+ 5	9	
7733	*Y Capricorni*	Max.	3100	Sept. 28	16	+14	5	Including rejected estimates would make it earlier
7944	*T Pegasi*	Max.	2968	May 19	29	0	0	Elements; diminishing when first seen in June
8068	*S Lacertae*	Max.	3089.0	Sept. 17	7	+79	9	A period of 236 days seems now most plausible.
"	"	Min.	3218	Jan. 24		–	2	$M - m = 107$. Corresponds with 2746; *A.J.* 314

Individual Observations.

6849 *R Aquilae.*
(Continued from 311)

Julian	Calendar	Mag.
d	1894	
2978	May 29	8.25_2
2991	June 11	6.97_2
3010	30	5.81_2

6849 *R Aquilae.* — Cont.

Julian	Calendar	Mag.
d	1894	
3018	July 8	6.34_2
3025	15	6.39_3
3029	19	6.36_2
3038	28	7.81_2

6849 *R Aquilae.* — Cont.

Julian	Calendar	Mag.
d	1894	
3052	Aug. 11	7.07_2
3063	22	7.92_2
3077	Sept. 5	8.69:
3087.6	15	8.93_2

6849 *R Aquilae.* — Cont.

Julian	Calendar	Mag.
d	1894	
3104.5	Oct. 2	9.58_2
3113.5	11	10.09_2
3129.6	27	10.65_2
3152.4	Nov. 19	11.36_2

6849 *R Aquilae.* — Cont.

Julian	Calendar	Mag.
d	1894	
3162.5	Nov. 29	11.62_2
3166.5	Dec. 3	11.86_2
3177.5	14	12.1]
3183.5	20	11.3]

6894 *S Lyrae.*

Julian d	Calendar 1894		Mag.
2988	June	8	12.0]
3017	July	7	11.6
3048	Aug.	7	10.9
3062		21	10.61_2
3078.6	Sept.	6	10.41_2
3083.6		11	9.92_2
3093.5		21	10.13_2
3103.5	Oct.	1	10.61_2
3107.6		5	10.5
3121.5		19	10.87_2
3129.5		27	11.32_2
3149.5	Nov.	16	11.48_2
3159		26	11.4
3177.5	Dec.	14	12.10_2
3188.5		25	12.7

6900 *W Aquilae.*

Julian d	Calendar 1894		Mag.
2988	June	8	13.0]
3017	July	7	12.0
3064	Aug.	23	10.4
3078.6	Sept.	6	9.43_2
3083.6		11	8.36_2
3093.6		21	8.60_2
3103.5	Oct.	1	8.06_2
3109.5		7	7.79_2
3121.5		19	8.18_2
3129.5		27	7.69_2
3134.5	Nov.	1	8.02_2
3136.6		3	7.88_2
3140.5		7	8.04_2
3148.4		15	8.26_2
3158.5		25	8.76_2

6903 *T Sagittarii.*

Julian d	Calendar 1894		Mag.
2983	June	3	8.1
2988		8	8.1
3001		21	8.0
3013	July	3	8.24_2
3017		7	8.08
3020		10	8.54
3030		20	8.57_2
3050	Aug.	9	9.68_2
3063		22	10.03_2
3072		31	10.36_2
3078.6	Sept.	6	10.48_2
3093.6		21	10.80_2
3101.5		29	11.07_2
3107.5	Oct.	5	11.47_2
3120.5		18	11.91_2
3122.5		20	11.91_2
3124.5		22	12.00_2
3134.5	Nov.	1	12.10_2
3149.5		16	11.3]

6905 *R Sagittarii.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
2983	June	3	7.7
2988		8	7.4
2994		14	7.08_2
2997	June	17	7.48_2
3003		23	6.96_2
3010		30	6.34_2
3017	July	7	7.58
3020		10	8.06
3030		20	8.09_2
3050	Aug.	9	9.3
3101.5	Sept.	29	11.89_2
3120.5	Oct.	18	12.63_2
3122.5		20	12.26_2
3124.5		22	12.5
3134.5	Nov.	1	12.30
3149.5		16	11.3]

(6915) *Sagittarii.*

Julian d	Calendar 1894		Mag.
3003	June	23	10.62
3010		30	10.25
3017	July	7	10.09
3020		10	10.12
3097.5	Sept.	25	10.71_2
3101.5		29	10.88
3120.5	Oct.	18	9.19
3122.5		20	10.78
3124.5		22	10.81
3134.5	Nov.	1	9.51
3135.5		2	9.79
3149.5		16	10.33_2:

6921 *S Sagittarii.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
2988	June	8	11.0
3001		21	10.1
3003		23	10.04_2
3010		30	10.20_2
3017	July	7	10.25_2
3020		10	10.73_2
3047	Aug.	6	11.34_2

6923 *Z Sagittarii.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
2988	June	8	12.2]
3020	July	10	12.4]
3047	Aug.	6	12.9
3063		22	12.5]
3092.6	Sept.	20	10.6
3093.5		21	10.45_2
3097.5		25	9.79_2
3101.5		29	9.73_2
3107.6	Oct.	5	9.38_2
3112.5		10	8.68_3
3117.5		15	8.36_2
3124.5		22	8.2
3133.5		31	9.27
3134.5	Nov.	1	8.63_2
3135.5		2	9.20_2
3137.5		4	8.89_2

— *Aquilae.*

DM. 12°4027

Julian d	Calendar 1893-4		Mag.
2684	Aug.	8	8.6
2687		11	7.64_2
2701	Aug.	25	7.64_2
2714	Oct.	7	8.05_2
2754		17	7.89_2
2784	Nov.	16	7.67_2
2818	Dec.	20	6.99_2
2824		26	7.15_2
2829		31	7.56_2
2994	June	14	7.45_2
3023	July	13	7.69_2
3062	Aug.	21	7.32_2
3065		24	7.52_2
3079.5	Sept.	7	6.69_2
3087.5		15	7.77_2
3093.5		21	7.98_2
3095.5		23	7.71_2
3097.5		25	7.01_2
3103.5	Oct.	1	7.61_2
3104.5		2	7.43_2
3112.5		10	7.68
3113.5		11	7.36_2
3117.5	Oct.	15	7.85_2
3167.5	Dec.	4	7.53_2
3168.5		5	7.35_2
3169.5		6	7.69_2
3185.5		22	7.97_2

7085 *RT Cygni.*

(Continued from 311.)

Julian d	Calendar 1894-5		Mag.
2994	June	14	6.95_2
2995		15	6.71_2
2997		17	6.53_2
2998		18	6.84_2
3000		20	6.78_2
3064	Aug.	23	10.0
3072.6		31	11.32_2
3079.5	Sept.	7	11.54_2
3083.6		11	11.52_2
3084.6		12	11.71_2
3087.6		15	11.61_2
3092.6		20	12.44_2
3094.6		22	12.43_2
3101.5		29	12.26_2
3108.5	Oct.	6	12.44_2
3120.5		18	12.27_2
3129.5		27	11.20_2
3135.5	Nov.	2	10.74_2
3144.5		11	10.17_2
3155.5		22	8.99_2
3166.5	Dec.	3	7.76_2
3168.5		5	7.75_2
3180.5		17	7.36_2
3185.5		22	7.29_2
3194.5		31	7.52
3198.5	Jan.	4	7.39_2
3208.5		14	8.05_2
3209.5		15	8.14_2

7118 *X Aquilae.*

Julian d	Calendar 1894		Mag.
2988	June	8	11.6
3014	July	4	10.2
3019	July	9	9.99_2
3023		13	9.36_2
3037		27	9.34_2
3050	Aug.	9	9.12_2
3063		22	9.52_2
3078.6	Sept.	6	10.34_2
3093.6		21	11.63_2
3104.5	Oct.	2	11.16_2
3108.5		6	12.44_2
3120.5		18	12.27_2
3131.5	Nov.	1	12.80_2
3149.5		16	12.4]
3159.5		26	12.2]
3177.5	Dec.	14	12.1]

7192 *Z Cygni.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
2978	May	29	7.89_2
2994	June	14	7.54_2
2995		15	7.43_2
2997		17	7.96_2
3000		20	8.26_2
3064	Aug.	23	11.3]
3072		31	11.3]
3084	Sept.	12	12.8]

7234 *R Capricorni.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
3095.6	Sept.	23	12.4
3105.5	Oct.	3	12.3
3121.5		19	12.14_2
3129.5		27	11.87_2
3134.5	Nov.	1	11.92_2
3148.5		15	12.08_2
3152.5		19	12.00_2
3158.5		25	12.32_2

7252 *W Capricorni.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
3065	Aug.	24	12.5]
3078.6	Sept.	6	12.8
3092.6		20	12.6
3095.5		23	12.98_2
3096.5		24	12.8
3097.6		25	12.43_2
3101.6		29	12.96_2
3103.6	Oct.	1	12.99_2
3105.5		3	13.05_2

7259 *RS Cygni.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
2994	June	14	7.59_2
2997		17	8.03_2
3026	July	16	7.84_2
3027		17	7.96_2
3028		18	7.95_2
3029		19	8.25_2
3062	Aug.	21	7.31_2
3072		31	8.02_2
3084.6	Sept.	12	7.62_2
3103.5	Oct.	1	8.10_2
3113.5		11	8.70_2
3117.5		15	8.10_2
3136.6	Nov.	3	8.51_2
3137.6		4	8.51_2
3160.5		27	8.62_2
3167.5	Dec.	4	8.25_2
3168.5		5	8.33_2
3169.5		6	8.41_2
3185.5		22	8.80_2

7261 *R Delphini.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
3017	July	7	8.4
3019		9	8.55_2
3026		16	8.33_2
3047	Aug.	6	8.73_2
3079	Sept.	7	10.1
3096.5		24	11.18_2
3107.6	Oct.	5	11.5
3121.5		19	12.23_2
3134.6	Nov.	1	12.33_2
3149.5		16	12.51_2
3152.5		19	12.69_2
3158.5		25	12.7
3162.5		29	12.8
3177.5	Dec.	14	12.6]
3183.5		20	12.7]
3194		31	11.5]

7455 *U Capricorni.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
3095.6	Sept.	23	11.5
3097.5		25	11.23_2
3105.5	Oct.	3	11.10_2
3121.5		19	10.33_2
3129.5		27	10.93_2
3134.5	Nov.	1	11.01_2
3148.5		15	11.75_2

7458 *V Delphini.*

(Continued from 311.)

Julian d	Calendar 1894-5		Mag.
3180.5	Dec.	17	12.2]
3181.5		18	12.4 :
3183.5		20	12.5 :
3195.5	Jan.	1	12.4]

7468 *T Aquarii.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
3064	Aug.	23	7.02_2
3070		29	7.38_2
3077	Sept.	5	6.90
3087.6		15	7.19_2
3092.6		20	7.85_2
3101.5		29	8.31_2

7571 *V Capricorni.*

(Continued from 311.)

Julian d	Calendar 1894		Mag.
3087.5	Sept.	15	9.42_2
3092.6		20	9.58_2

7571 *V Capricorni*.—Con.

Julian	Calendar	Mag.
d	1894	
3095.6	Sept. 23	10.50_2
3101.6	29	9.18_2
3103.6	Oct. 1	9.12_2
3107.6	5	9.66_2
3108.5	6	9.88_2
3112.5	10	9.6
3117.5	15	10.41_2

7659 *T Capricorni*.

(Continued from 311.)

Julian	Calendar	Mag.
	1894	
3095.6	Sept. 23	11.4

7659 *T Capricorni*.—Con.

Julian	Calendar	Mag.
d	1894	
3105.5	Oct. 3	11.4
3122.5	20	10.3
3129.5	27	9.47_2
3134.5	Nov. 1	9.18_2
3136.6	3	9.20_2
3144.5	11	9.30_2
3145.5	12	9.29_2
3148.5	15	8.99_2
3152.5	19	8.71_2
3155.5	22	9.50_2
3159.5	26	9.11_2
3161.5	28	9.55_2

7733 *Y Capricorni*.

(Continued from 311.)

Julian	Calendar	Mag.
d	1894	
3072	Aug. 31	11.1]
3079.5	Sept. 7	12.5
3092.6	20	12.3
3093.6	21	12.2
3095.6	23	12.50_2
3101.6	29	12.41_2
3105.5	Oct. 3	12.51_2
3121.5	19	12.9

7941 *T Pegasi*.

Julian	Calendar	Mag.
	1894	
2988	June 8	10.1
3011	July 1	11.2

8068 *S Lacertae*.

(Continued from 314.)

Julian	Calendar	Mag.
d	1894	
3011	July 1	11.6
3048	Aug. 7	8.8
3058	17	8.7
3062	21	8.60
3070	29	8.50_2
3079.5	Sept. 7	7.90_2
3083.5	11	7.68_2
3092.6	20	7.77_2
3096.6	24	7.95_2
3103.6	Oct. 1	7.99_2
3109.5	7	7.95_2

8068 *S Lacertae*.—Con.

Julian	Calendar	Mag.
d	1894 5	
3118.5	Oct. 16	8.69^2
3136.6	Nov. 3	10.15_2
3158.5	25	10.98_2
3181.5	Dec. 18	11.93_2
3191.5	31	12.1
3208.5	Jan. 14	12.4
3214.5	20	12.4]
3220.5	26	12.0]
3221.5	27	12.4]
3236.5	Feb. 11	12.2

COMPARISON-STARS.

6894 *S Lyrae*.

D	+25°3756		7.0	0
K	+25°3745		8.04	2M
1*N*	+24°3668		8.63	3M
1*Q*	+24°3659		8.62	2M
R	+25°3748		8.69	3
2*S*	+25°3762		9.14	2M
Z	+25°3750		10.42	7
1*Z*	+25°3752		10.28	7
e	2*n*3*p*	1*Z*	11.01	7
f	7*n*7*p*	*D*	11.56	4

6894 *S Lyrae*.—Cont.

j	6*n*1*f*	*f*	12.37	2

6900 *W Aquilae*.

D	−6°5103	6.65	1
H	−6°5092	7.69	3
S	−7°4912	9.19	4
T	−7°4902	9.48	14
1*T*	−7°4906	9.21	2
U	−7°4894	9.51	2
1*U*	−7°4905	10.21	7

6900 *W Aquilae*.—Cont.

X	−7°4895	10.40	2
Y	−7°4896	10.94	4

7118 *X Aquilae*.

C	+4°4264	6.88	0V
D	+3°4172	6.65	1V
H	+4°4243	8.39	3
P	+3°4176	8.98	5
Q	+3°4170	8.65	6
1*Z*	+4°4246	10.75	1

7118 *X Aquilae*.—Cont.

2*Z*	+4°4255		10.39	1
3*Z*	+4°4257		10.20	3
4*Z*	+4°4242		10.36	3
b	9*n*7*f*	*H*	10.83	6
d	9*np*	*Q*	11.24	1
g	7*n*1*f*	*Q*	11.78	4
i	3*s*	*V*	12.13	3
m	3*p*	*V*	13.07	1

OBSERVATIONS OF (84) *CLIO*, (113) *AMALTHEA* AND (175) *ANDROMACHE*.

MADE AT THE CINCINNATI OBSERVATORY,

BY PHILLIPS ISHAM.

1894 Cincinnati M.T.	*	No. Comp.	☄ — *		☄'s apparent		log *p*Δ	
			Δα	Δδ	α	δ	for α	for δ
				(84) Clio.				
h m s			m s	′ ″	h m s	° ′ ″		
July 21 11 22 51	1	8	−0 35.86	−2 25.8	21 8 3.62	−24 1 23.5	*n*9.300	0.883
25 10 21 43	1	8	−1 33.27	+0 45.7	21 7 6.22	−23 58 11.9	*n*9.485	0.863
27 10 43 58	2	9	+0 25.90	−6 48.8	21 5 1.32	−23 51 1.4	*n*9.392	0.875
Aug. 3 10 24 17	3	7	+2 16.00	−4 55.1	20 57 26.45	−23 22 18.7	*n*9.334	0.879
4 10 22 16	3	8	+1 9.77	−0 13.4	20 56 20.22	−23 17 37.1	*n*9.321	0.879
6 10 31 20	4	8	+0 11.78	−0 55.7	20 54 6.93	−23 7 46.5	*n*9.216	0.884
9 11 21 15	5	8	−1 20.43	+2 21.6	20 50 48.40	−22 51 45.1	*n*8.509	0.891
				(113) Amalthea.				
Sept. 7 10 42 26	6	8	−1 42.73	+0 3.6	22 7 21.14	−16 13 18.2	*n*8.523	0.860
				(175) Andromache.				
Aug. 6 10 52 52	7	8	+0 30.62	+3 9.6	22 32 49.18	−13 45 35.0	*n*9.475	0.824
Sept. 7 10 11 8	8	8	+0 46.52	+2 42.9	22 9 44.01	−15 34 32.8	*n*9.011	0.855
8 9 49 41	8	8	+0 6.83	+0 38.0	22 9 4.35	−15 36 37.6	*n*9.135	0.853
19 9 42 4	9	8	−1 6.66	−1 26.5	22 2 47.78	−15 51 0.9	*n*8.710	0.858
21 10 0 8	9	8	−5 0.09	−2 20.9	22 1 54.42	−15 51 55.2	7.657	0.859
25 8 0 9	10	8	+4 15.18	+2 13.9	22 0 25.80	−15 52 2.1	*n*9.307	0.848
26 10 7 17	10	8	+3 54.23	+2 31.8	22 0 4.85	−15 51 44.3	8.806	0.858
27 8 18 40	10	8	+3 38.29	+3 3.6	21 59 48.90	−15 51 12.6	*n*9.178	0.853
29 11 29 8	10	8	+3 5.30	+4 22.1	21 59 15.88	−15 49 54.3	9.395	0.842
Oct. 1 7 27 28	10	8	+2 43.25	+6 3.2	21 58 53.81	−15 48 13.3	*n*9.336	0.846

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 8 35.96	+3.52	−23 59 6.1	+ 8.4	Cordoba Z.C. XXI, 229
2	21 4 31.85	+3.57	−23 44 20.8	+ 8.2	Argentine G.C. 29038
3	20 55 6.76	+3.69	−23 17 30.9	+ 7.3	Argentine G.C. 28796
4	20 53 51.46	+3.69	−23 6 57.8	+ 7.0	Argentine G.C. 28759
5	20 52 5.12	+3.71	−22 54 13.6	+ 6.9	Cincin. Mer. Circle, 1 obs.
6	22 9 0.20	+3.67	−16 13 35.9	+14.1	Cincin. Mer. Circle, 2 obs.
7	22 32 15.29	+3.27	−13 48 59.9	+15.3	Bonn VI, 3 obs.
8	22 8 53.86	+3.66	−15 37 29.9	+14.2	Cincin. Mer. Circle, 1 obs.
9	22 6 50.80	{+3.64} {+3.71}	−15 49 47.9	+13.5	Cincin. Mer. Circle, 2 obs.
10	21 56 7.01	{+3.61} {+3.55}	−15 54 28.5	{+12.5} {+12.0}	Bonn VI, 21ʰ,68; Cincin. Mer. Circle, 1 obs.

OBSERVATIONS OF ENCKE'S COMET,

MADE AT THE WESLEYAN UNIVERSITY OBSERVATORY, MIDDLETOWN, CONN., WITH 12-INCH REFRACTOR,

By W. S. EICHELBERGER.

1895 Greenwich M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Jan. 17 12 3 13	1	5	−1 42.01		21 57 40.56		9.632	
23 11 20 44	2	10 , 5	+0 5.26	−4 23.3	21 38 58.84	−5 17 14.9	9.633	0.776

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 59 23.37	−0.80			Yarnall 9937
2	21 38 54.38	−0.80	−5 12 43.3	−8.3	Yarnall 9756

OBSERVATION OF COMET *e* 1894.

This object was observed at the Chamberlin Observatory by Dr. H. A. Howe, who saw it as an extremely faint patch of nebulosity, devoid of condensation. It was, when first seen, so near a star of the eleventh magnitude, that its motion soon caused it to disappear in the glare of the star, and it was judged best to assume that it coincided with the star.

1895 Denver M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
Jan. 19 8ʰ 30ᵐ	11	1 , 1	0ᵐ 0ˢ.00	0′ 0″.0	0ʰ 58ᵐ 38ˢ.01	+6° 17′ 22″.2	9.556	0.708

Mean Place for 1895.0 of Comparison-Star.

*	α	Red. to app. place	δ	Red. to app. place	Authority
11	0ʰ 58ᵐ 38ˢ.06	−0ˢ.05	+6° 17′ 19″.9	+2″.3	Microm.-comp. with Piazzi 269, which it foll. 18ˢ.12, 5′ 16″.1 north.

NOTE ON THE NEBULA DREYER N.G.C. No. 532,

By E. E. Barnard.

On Jan. 28, while waiting for the comet to pass by a very small star that interfered with its visibility, I measured the position of the center of brightness of an extremely elongated nebula that was in the field, south preceding the comparison-star. This nebula I find is Dreyer N.G.C., No. 532.

Neb.—star, $\Delta\alpha = -15^s.70$ (3 obs.), $\Delta\delta = -2'\,26''.4$ (2 obs.)

This gives the place of the nebula for 1860.0.

$$\alpha = 1^h\,17^m\,57^s.6, \quad \delta = +8^\circ\,32'.0$$

I also measured the position-angle of the axis of the nebula:

$$\text{P.A.} = 27^\circ.9 \text{ (2 obs.)}$$

Its width from one setting of the wires = 32″ and its length was nearly 4′. It is a very thin, extremely long, slender nebula, a little brighter about the middle to nearly a faint nucleus. This brightest part I called 14^M. The above place agrees fairly with the one in the New General Catalogue of Nebulas.

Mt. Hamilton, 1895 *Jan.* 30.

OBSERVATIONS OF SUSPECTED VARIABLES,

By J. A. Parkhurst.

(291) — *Cassiopeae* = DM. 57°165.

According to Espin (*A.N.* No. 3261) this star decreased from $8^M.6$ 1894 Sept. 2, to $9^M.8$ Oct. 29. My observations are:

		M
1894 Dec.	5	11.3 (moon.)
	17	11.5
	20	11.3
	29	11.1
1895 Jan.	23	10.6
Feb.	21	10.1
	23	9.9

The redness of the star does not seem sufficient to account for its change in light.

(691) — *Persei.*

I have looked for this star on the following dates: 1892 Dec. 3, 8, 23. 1893 Aug. 3, 11, 17; Oct. 9; Dec. 5. 1894 Jan. 26; Feb. 5, 27; Mar. 6, 12, 26; Apr. 5; May 3; June 24; Nov. 21; Dec. 17. 1895 Jan. 23; Feb. 15, 21. In no case has anything brighter than 12^M been seen at the place nor has any change been detected in the faint stars in the vicinity.

(780) — *Persei.*

This star was observed eighteen times from 1894 Apr. 16 to 1895 Jan. 26, at least one observation being made in each month except September and October. The extreme limits of change noted were $8^M.9$ and $9^M.4$, no more than would be expected in estimates of so red a star.

Marengo, Ill., 1895 *Feb.* 28.

COMETS OF THE YEAR 1894.

The dates are in Greenwich Mean Time, and the Elements only approximate.

Designation	Perihelion	Ω	ω	i	q	ϕ	Discoverer	Date	Synonym	
		° ′	° ′	° ′		° ′				
I	Feb. 9.727	83 52	46 56	5 35	1.1508	45 18	Denning	March 26	*a* 1894	Periodic
II	April 13.520	206 21	324 18	87 3	0.9834		Gale	April 1	*b* 1894	
III	April 23.247	121 10	185 5	12 44	1.3506	33 26	Finlay	May 8	*c* 1894	Periodic
IV	Oct. 12.188	48 45	296 35	2 58	1.3920	34 52	Swift	Nov. 20	*e* 1894	Periodic

The periodic comet of Encke, *d* 1894, first seen by Cerulli Nov. 1, passed its perihelion in 1895 (Feb. 7.74).

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Comets of the Year 1894.

Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed March 9.*

THE

ASTRONOMICAL JOURNAL.

No. 340.

VOL. XV. BOSTON, 1895 MARCH 19. NO. 4

MICROMETRIC MEASURES OF THE TWO OUTER SATELLITES OF *URANUS*, AND OF THE SATELLITE OF *NEPTUNE*,

By J. M. SCHAEBERLE.

These miscellaneous observations were primarily made for the purpose of furnishing computers additional data for investigations relating to the masses of *Uranus* and *Neptune*.

In measuring the position-angle, the micrometer thread was made to bisect the planetary disk in each case. As both of the disks are small the error resulting from a faulty eye-estimate in bisecting can probably be regarded as being less than the other errors of observation. All the measures were made with an eye-piece magnifying 520 diameters, and with bright thread illumination.

Satellites of *Uranus*.

Oberon.

Date	Pacific Standard Time	No. of Obs.	Position Angle	Distance	Remarks	Date	Pacific Standard Time	No. of Obs.	Position Angle	Distance	Remarks
1894	h m s		°	″		1894	h m s		°	″	
Apr. 4	14 54 4	4	34.67	42.78	Cloudy, satellite dim	June 20	9 16 52	4	300.10	37.69	
	12 11 26	8					9 28 27	10			
	12 27 22	4	35.35				9 40 30	4	301.32		
Apr. 7	13 6 34	4	125.62	40.01	Windy and poor seeing	June 26	9 50 0	5	97.62	36.54	
	13 25 30	8					10 4 24	10			
	13 40 52	4	126.37				10 16 30	5	97.86		
Apr. 28	11 16 35	3	325.37	41.72		July 4	9 3 50	3	315.00	39.24	
	11 38 33	10					9 12 50	6			
	11 56 30	3	326.33				9 24 50	3	315.93		
June 19	10 35 35	4	270.12	36.61		July 6	9 14 40	3	3.97	44.35	
	10 45 5	10					9 24 20	6			
	10 57 27	4	270.95				9 34 40	3	4.23		

Titania.

Date	Pacific Standard Time	No. of Obs.	Position Angle	Distance	Remarks	Date	Pacific Standard Time	No. of Obs.	Position Angle	Distance	Remarks
1894	h m s		°	″		1894	h m s		°	″	
Apr. 4	12 35 41	4	123.02	29.39	Cloudy, satellite dim	Apr. 28	12 34 54	5	27.84	32.70	
	12 48 45	8					13 7 45	10			
	13 2 7	4	123.75				13 23 7	4	27.90		
Apr. 7	13 49 36	4	239.95	29.64	Windy and poor seeing	June 19	9 30 20	4	14.02	33.01	
	14 6 30	8					9 45 29	10			
	14 31 37	4	241.40				10 2 5	4	14.82		

Date	Pacific Standard Time	No. of Obs.	Position Angle	Distance	Remarks
1894	h m s		°	"	
	9 49 7	4	52.67		
June 20	10 4 42	10		29.83	
	10 20 0	4	53.10		
	8 55 30	4	308.85		
June 26	9 17 40	12		28.79	Poor seeing
	9 35 30	4	310.72		
1894	h m s		°	"	
	9 32 50	3	276.90		
July 4	9 44 25	6		26.78	
	9 59 50	3	277.57		
	8 52 50	3	359.60		
July 6	9 2 10	6		33.18	
	9 9 10	3	360.10		

SATELLITE OF *Neptune*.

In the morning hours of the night of 1892 Sept. 24, while examining *Neptune* in a remarkably clear and steady atmosphere, I observed a star quite close to the planet, but so faint that it was near the limit of vision of the 36-inch refractor. Its dull appearance under the exceptionally fine seeing led me to regard it in a suspicious light and the following observations were at once made with the position micrometer. Every measure made for position-angle is here given.

Pac. Standard Time	Position Angle	Pac. Standard Time	Position Angle
h m	°	h m	°
15 15	101.9	16 6	98.3
15 25	102.1	16 15	98.3
15 40	100.8	16 37	97.9
15 48	99.9	16 43	97.8
16 0	99.0		

After the last of the above observations the morning twilight began to interfere with farther measures. A final measure at 16h 55m gave a position-angle of 99°.0, but the observation was very unsatisfactory, owing to the increased brightness of the field of view, resulting in the almost complete obliteration of the suspected object.

At 16h 23m the distance from the planet's center was — according to the mean of three measures — found to be 24".4. The geocentric motion of the planet with reference to a fixed star in place of the suspected object would account for only 1° 20′ of the total change in position-angle, leaving nearly 2° of angular motion still unaccounted for. As the motion of a satellite at the measured distance would be something less than one-half of the whole change in position-angle, the quantity unaccounted for is probably due to errors of observation, for since that date I have often examined the immediate neighborhood of *Neptune*, but no measurable object in apparent orbital motion about the planet has again been recognized. It is proper to state, however, that on no subsequent occasion has the seeing been considered equal to that of 1892 Sept. 24. Professor HOLDEN has several times requested me to publish the observations, and, as they seem very properly to form part of the micrometric measures of this paper, I now, somewhat reluctantly, mention these simple facts.

OBSERVATIONS OF THE SATELLITE OF *Neptune*.

Date	Pacific Standard Time	No. of Obs.	Position Angle	Distance	Remarks
1894-5	h m s		°	"	
	7 32 15	4	259.35		
Apr. 5	7 46 18	8		14.60	
	7 58 0	4	258.63		
Apr. 11	8 9 51	8		14.85	Wretched seeing Obs. very poor and unreliable
	8 10 41	8	254.94		
	8 7 24		299.58		
Dec. 13	8 23 58			10.98	
	8 44 48		297.88		
	7 34 49	5	49.43		
Jan. 10	7 48 40	10		15.85	
	8 4 43	5	48.77		
	10 8 31	5	208.12		
Jan. 25	10 24 4	10		12.93	
	10 45 7	5	206.32		
	9 24 45	5	122.30		
Jan. 26	9 42 38	10		10.84	
	9 57 26	5	121.16		
1895	h m s		°	"	
	9 42 7	5	295.28		
Jan. 29	10 12 57	10		11.48	Poor seeing
	10 41 16	5	293.44		
	7 29 56	5	249.72		
Jan. 30	7 49 18	10		16.45	Poor seeing
	8 5 17	5	248.04		
	8 21 46	5	206.15		
Jan. 31	8 45 59	10		12.17	Poor seeing
	9 5 11	5	203.67		
	7 54 29	5	66.97		
Feb. 2	8 11 30	10		16.84	
	8 25 34	5	66.31		
	7 47 15	5	24.54		
Feb. 3	8 1 33	10		12.24	
	8 19 6	5	22.54		
	7 36 28	5	199.40		
Feb. 6	7 48 24	10		11.75	
	8 1 54	5	198.42		

Lick Observatory, 1895 *Feb.* 9.

LATITUDE-DETERMINATION AT THE SAYRE OBSERVATORY,

By C. L. DOOLITTLE.

The results of the latitude work at this place to the end of the year 1893 may be found in no. 322 of this Journal. Since that time observations have been continued, and are still in progress, but on a somewhat different plan. Instead of eleven groups of stars, four only have been employed, as proposed by Dr. Küstner (*Astr. Nach.* No. 3015). The four groups are distributed as follows:

I	Right-Ascension	5h 31m	to	7h 23m	10 pairs
II	" "	14 1	to	15 51	10 "
III	" "	17 30	to	19 35	9 "
IV	" "	21 28	to	23 52	11 "

In the tabular statement following, the Roman numerals I, II, III, IV refer to these groups.

All of the pairs employed are found in the observing list of 1892–93. The mean declinations resulting from the adjustment of the former series have been used throughout. A future rediscussion of the declinations may introduce slight modifications, but this will not be undertaken at present.

The daily means are as follows:

$$\varphi = 40^\circ\ 36'\ 20''+$$

1894	I	Obs.	II	Obs.
	″		″	
Jan. 19	3.31	10	–	–
25	2.77	10	–	–
27	3.20	10	3.24	8
28	3.41	7	–	–
30	2.89	10	–	–
31	3.30	9	–	–
Feb. 1	–	–	3.48	9
4	–	–	2.83	3
5	3.21	9	–	–
6	3.18	10	–	–
11	3.11	9	3.03	2
15	3.14	9	–	–
16	3.23	7	3.29	8
19	3.11	3	–	–
20	2.86	3	–	–
23	3.03	10	2.96	8
24	2.89	10	3.18	9
26	–	–	3.37	9
27	3.44	9	–	–
Mar. 3	3.36	10	3.46	8
4	3.24	10	3.36	9
7	3.49	10	–	–
8	3.16	7	3.26	3
12	3.31	10	–	–
13	–	–	3.27	5
14	3.21	10	3.24	10
16	2.86	6	3.17	10
17	3.27	8	3.16	2
18	3.16	8	–	–
19	–	–	3.00	8
Apr. 6	–	–	3.45	1
9	–	–	3.10	9
13	–	–	3.41	10
14	–	–	3.25	10
15	–	–	3.10	10
16	–	–	3.30	2
22	–	–	3.30	10
24	–	–	3.01	10
25	–	–	3.13	10
26	–	–	3.22	10
30	–	–	3.27	9
		214		202

1894	II	Obs.	III	Obs.
	″		″	
May 8	3.08	10	3.19	8
9	2.86	10	3.12	8
10	3.04	9	3.30	3
12	2.89	10	3.11	9
13	2.99	4	–	–
26	3.03	10	2.94	9
27	2.90	8	3.11	9
June 3	2.70	7	–	–
4	2.58	6	–	–
8	3.00	7	–	–
9	2.86	9	–	–
10	3.01	9	3.10	9
11	–	–	2.87	1
12	2.99	3	–	–
14	3.00	9	2.90	5
15	3.01	9	3.04	9
17	2.95	9	3.03	7
18	2.91	3	–	–
20	3.03	8	3.00	8
22	2.88	8	2.93	7
27	2.90	8	–	–
28	3.00	8	2.98	9
July 3	2.85	7	2.90	8
5	2.85	7	2.88	4
		178		113

1894	III	Obs.	IV	Obs.
	″		″	
July 9	3.13	9	3.01	11
10	2.88	4	–	–
11	3.42	1	–	–
12	2.86	9	3.11	11
13	3.01	9	3.05	11
17	3.00	9	3.10	4
24	3.23	8	3.30	10
25	3.26	9	3.22	11
Aug. 5	3.04	8	3.13	11
6	2.73	9	2.86	11
9	2.97	9	2.74	11
10	3.04	9	2.86	10
20	3.01	7	2.98	10
21	2.91	9	–	–
22	3.08	9	3.05	11
23	3.00	9	2.99	11
24	3.02	9	3.08	10
31	2.95	9	2.99	11
Sept. 7	2.99	8	–	–
11	2.91	9	3.14	11
12	3.05	8	2.99	11
15	2.82	8	3.11	11
		178		187

1894	IV	Obs.	I	Obs.
	″		″	
Oct. 2	3.14	10	–	–
5	3.14	11	–	–
6	3.17	11	3.33	8
11	3.25	5	3.20	10
15	3.17	10	–	–
16	3.05	11	3.14	9
17	3.15	10	3.27	10
18	3.01	11	3.25	10
19	3.26	11	3.08	10
20	3.12	11	–	–
27	3.22	10	3.18	10
31	–	–	3.18	10
Nov. 1	3.12	11	3.29	10
2	2.89	7	–	–
3	–	–	3.24	10
4	3.20	11	–	–
6	–	–	3.13	6
10	–	–	3.21	10
11	3.24	11	3.39	10
12	3.28	10	–	–
15	3.12	11	3.38	8
16	3.15	9	3.32	9
19	3.02	10	3.31	10
20	3.29	11	–	–
21	3.26	11	–	–
22	3.10	10	–	–
24	–	–	3.25	7
26	3.29	11	–	–
27	2.75	10	3.58	3
28	2.99	11	–	–
29	3.34	11	–	–
Dec. 3	3.28	9	3.34	10
4	3.14	10	3.35	10
5	3.21	10	3.18	10
6	2.93	10	3.31	9
		305		199

These have been combined to form the mean values which follow.

	P.M.	Obs.	A.M.	Obs.	½(PM+AM)
	″		″		
Jan. 19 – Feb. 16	3.149	100	3.272	30	3.210
Feb. 19 – Mar. 4	3.165	55	3.269	43	3.217
Mar. 7 – Mar. 19	3.229	59	3.173	38	3.201
Apr. 6 – Apr. 30	–	–	3.204	91	3.204
May 8 – June 11	2.923	99	3.097	56	3.010
June 12 – July 5	2.946	79	2.967	57	2.956
July 9 – Aug. 10	3.021	93	3.032	101	3.028
Aug. 20 – Sept. 15	2.974	85	3.039	86	3.006
Oct. 2 – Oct. 31	3.145	111	3.204	77	3.174
Nov. 1 – Nov. 20	3.155	91	3.290	73	3.222
Nov. 21 – Dec. 6	3.132	103	3.305	49	3.218
		875		701	

Bethlehem, Pa., 1895 *March* 2.

OBSERVATIONS OF LONG-PERIOD VARIABLES,

BY PAUL S. YENDELL.

5758. *X Herculis.*

Twenty-nine observations of this star have been obtained between 1894 March 7 and November 29.

The star was nearly at minimum light when first observed, and changed very slowly until the end of May. A very uncertain minimum of $7^{M}.0$ is indicated on May 3±. A rather sharp rise to $6^{M}.0$ took place from May 29 to July 7, and the star remained nearly at this brightness until August 16, when it began to decline. A maximum is indicated about July 9; a very bright minimum seems to have occurred on September 6–7, the light being $6^{M}.4$, followed by a rise to $5^{M}.9$, which was reached on November 2–4. At the last observation it had apparently declined to $6^{M}.1$, but this is not very certain, as the star was then low in the northwest.

5830. *R Scorpii.*

On account of its low southern declination, this star is a difficult object for my telescope, and only one comparison-star has been used for it, DM. −22°4139, $9^{M}.2$; the Cordoba DM. rates it as $9^{M}.4$, and PARKHURST gives the photometric magnitude $10^{M}.18$. On account of these differing estimates of the comparison-star, and the uncertainty of the value of the step, no estimates of magnitude have been attempted, but the individual step-estimates will be given below, the comparison-star being = 5.0.

Seven observations were made, from 1894 June 20 to August 5, showing a maximum on July 6. The individual observations are:

1894 June	20	3.0
	21	1.0
July	2	8.0
	9	8.0
	24	3.0
	30	1.0
Aug.	5	1.0

5831. *S Scorpii.*

The remarks on the difficulties of observation in the case of 5830 apply equally to 5831. Four observations were secured as follows, the same comparison-star being used as for 5830. They are:

1894 July	9	*a4r*	1.0
	24	*a5r*	0.0
Aug.	5	*a8–9r*	−3.5

It seems possible that the star passed its maximum during the interval between July 9 and 24, when no observations could be had.

6005. *S Draconis.*

From the slowness of this star's light-changes, it is rather seldom observed; but ten observations, from 1894 May 10 to Dec. 15, show a well-marked maximum of $7^{M}.8$ on October 28. The observations are mostly grouped within six weeks of the maximum, so that the phase is very definitely marked.

6794. *R Lyrae.*

R Lyrae was observed from 1894 October 6 to 1895 January 4, twenty-four times.

Assuming the magnitude of *η Lyrae* to be $4^{M}.5$, and that of F. 16 *Lyrae* at $5^{M}.2$, on the first-named date *R* was estimated as $4^{M}.3$; it declined to a minimum of $4^{M}.8$ on October 27. From this point it increased to a maximum of $4^{M}.2$ on November 28, which was followed by a sharp decline to a minimum of $4^{M}.8$, which was passed December 16. When last observed, the star was again slowly increasing, and was apparently about $4^{M}.6$.

6943. *T Sagittae.*

T Sagittae was observed only thirteen times during the season. These observations indicate a minimum of $9^{M}.4$ on June 4, the star's brightness at the first observation having been $9^{M}.0$. A maximum of $8^{M}.8$ is indicated on August 5, and at the last observation, on November 29, the star had fallen to $9^{M}.4$.

7085. *RT Cygni.*

Since the observed maximum published in no. 323, I have observed this star sixteen times. It was looked at on 1894 October 28, and was then estimated as not brighter than $10^{M}.5$. Observations for a maximum were begun on November 22, at which date it was $10^{M}.0$. This was followed by the rapid increase which is apparently characteristic of the star's variation, and on December 5 its brightness was estimated as $7^{M}.4$. A further increase to $7^{M}.1$ took place between December 5 and 17, and the maximum is indicated on December 18. At the last observation, on 1895 January 17, the star's brightness was by estimation $8^{M}.1$.

7351. *RW Cygni.*

During the year 1894 I observed 7351 eleven times. The dates and estimated magnitudes are

	M	
1894 Jan. 1	9.6	
May 10	10.1	
22	10.0 ±	eye-estimate
June 3	10.1	
20	9.4	
July 3	9.4	
Aug. 22	9.4	
31	9.2	
Oct. 28	9.2	
Nov. 22	8.9	

A minimum of $10^{M}.1$ seems to have occurred about May 31.

Dorchester, Mass., 1895 *Feb.* 1.

7450. *V Aquarii.*

I have fifteen observations of *V Aquarii*, between 1894 June 1 and December 15. At the first observation the star's light was $8^{M}.5$. It decreased gradually to a minimum of $9^{M}.8$, which is very definitely indicated on Oct. 17. The increase has been steady and comparatively quick, and at the last observation, on Dec. 15, it had reached $8^{M}.5$.

7560. *R Vulpeculae.*

I began observing *R Vulpeculae* on 1894 November 22, its brightness at that date being $9^{M}.5$. It rose very regularly and rapidly to a distinctly indicated maximum of $8^{M}.2$, which took place on Dec. 15. The decline has been rather slower, and when last observed, on 1895 January 4, it had reached $9^{M}.0$.

7783. *RU Cygni.*

I have observed *RU Cygni* thirteen times, from 1894 May 10 to Dec. 22. Its changes, though slow, have been very decided, and the star has risen from $8^{M}.7$, its brightness at the first-named date, to a maximum of $7^{M}.5$, which was passed about September 5. The brightness at the last observation was $8^{M}.7$.

8591. *V Cephei.*

This star has been observed nineteen times during the year, from 1894 January 14 to 1895 January 23. A maximum of $6^{M}.3$ is indicated on 1894 January 27, and a minimum of $7^{M}.0$ on May 12. It appears to be now near another maximum, being about $6^{M}.2$.

FINDING-EPHEMERIS FOR COMET 1889 V,

By CHARLES LANE POOR.

The following ephemeris was computed with the elements given in *Astronomical Journal*, no. 320, which are osculating for 1896 Oct. 22.5, Greenwich Mean Time. The right-ascensions and declinations are apparent, but the times are not corrected for aberration. The corrections to the places, due to the perturbations during the interval 1895 May to 1896 October, are,

$$\Delta\alpha = +3^{s}.3 \qquad \Delta\delta = -10''$$

It will be recalled that there was an uncertainty in the elements used in my previous work, which uncertainty was expressed by the indeterminate, r. The ephemeris is computed for the mean set of elements, or for $r = 0$. Giving r its greatest positive and negative values, we find that the corresponding corrections to the ephemeris may amount to,

$$\Delta\alpha = \pm 2^{m} \qquad \Delta\delta = \pm 12'$$

The comet at this opposition should be extremely faint, not quite so bright as when last observed at the Lick Observatory in 1891. But it is to be hoped that it may be rediscovered and a few observations obtained.

Ephemeris for Greenwich Mean Midnight.

1895	Apparent α	App. δ	log. Δ	Bright.
	h m s	° ′		
April 12.5	15 43 51	−24 2.0	0.51871	0.04
16.5	15 41 48	−24 1.3		
20.5	15 39 31	−23 59.5	0.50594	
24.5	15 37 0	−23 56.6		
28.5	15 34 17	−23 52.7	0.49510	0.05
May 2.5	15 31 24	−23 47.7		
6.5	15 28 23	−23 41.8	0.48655	
10.5	15 25 17	−23 34.9		
14.5	15 22 7	−23 27.2	0.48056	0.06
18.5	15 18 55	−23 18.7		
22.5	15 15 44	−23 9.5	0.47728	
26.5	15 12 37	−22 59.9		
30.5	15 9 36	−22 50.0	0.47673	0.06
June 3.5	15 6 43	−22 39.9		

ON THE ORBIT OF (313) *CHALDAEA* AND ASTEROID *AW*.

FROM A LETTER OF MR. BERBERICH.

With your permission I will send you some remarks concerning planet (313) *Chaldaea*. In *Astron. Journal*, no. 322, Prof. Boss published an ephemeris for the opposition in 1894, deduced from my elements in the *Astron. Jahrbuch*. These elements are computed from the first apparition (1891) only. Then the perturbations by *Jupiter* were rather important and may not be neglected in the prediction of the planet's place for future times. The elements of planet (313), including these perturbations, are, for Berlin Mean Time.

Epoch =	1891 Sept. 8.0	1893 Feb. 9.0	1894 July 14.0	1895 Sept. 27.0
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
M =	228 3 46.0	7 28 58.1	147 15 35.5	265 32 19.4
ω =	312 42 53.2	313 3 42.5	313 6 27.1	313 10 19.3
☊ =	176 35 10.2	176 35 8.8	176 34 29.2	176 42 37.6
i =	11 31 41.3	11 31 53.1	11 34 49.0	11 34 53.2
ϕ =	10 21 52.0	10 21 11.3	10 22 20.1	10 23 26.2
μ =	967″.0469	968″.3299	968″.0759	968″.5338
$\log a$ =	0.376373	0.375989	0.376065	0.375928
M. Equin. =	1890.0	1890.0	1890.0	1900.0

Now the large correction of the ephemeris, $+1^m\ 13^s$, as indicated by Prof. Boss's observation, will be reduced to a few seconds, and we may suppose that these elements will give the place of the planet at the next opposition very near to the true one. I shall delay the improvement of the orbit until the observations made in 1894 shall have been published.

Planet (313) is of some interest on account of its brightness and its small distance from the earth when near perihelion. It may contribute to our knowledge of the Solar Parallax.

The planet *AW*, discovered by Dr. H. C. WILSON on a photograph of the *Pleiades*, should be in opposition on April 13. The place and daily motion, as derived from the circular orbit, are, April 13.5 Berlin Mean Time:

$$\alpha = 13^h\ 28^m.1\ ,\ \delta = -9°\ 35',\ \Delta\alpha = -1^m.0\ ,\ \Delta\delta = +3'.7$$

Brightness about 12^M.

As the planet is very near its descending node, a search along the ecliptic for some 20 degrees would permit its rediscovery. But that can be done suitably except by the aid of photography.

The numeration of the planets *BD* to *BN* can not yet be assigned, inasmuch as the orbits of three of them are still to be computed. As soon as this shall be done, I will inform you of the results. Probably *BN* will become = 398, *BD* receiving no number, *BJ* = 369.

Berlin, 1895 *Feb.* 24.

ON THE VARIABLE STARS 7247 *RX CYGNI* AND 8116 *W CEPHEI*,

BY PAUL S. YENDELL.

7247. *RX Cygni*.

As the variability of this star has been contested by HARTWIG, I have continued my watch on it during the past season, from 1894 May 9 to Dec. 22, during which time I have observed it thirty-seven times. The result of these observations has been to confirm my impression that the star is variable to the extent of about half a magnitude, though the suggestion of a short period has not been borne out.

The changes appear to be quite irregular, and the range observed has been from $8^M.4$ to $7^M.8$, altogether too large a difference to be imputed to errors of observation, as intimated by HARTWIG, in the preface to his Ephemeris for 1895. My observations for color show no trace of redness in the star, so that the differences observed cannot be accounted for on this score. The difficulty of the magnitude-estimates is enhanced by the errors of the DM. magnitudes of the comparison-stars +47 3022 and 3025, which are respectively $8^M.0$ and $8^M.1$, while my comparisons show an interval of four steps, representing three or four-tenths of a magnitude.

By the best magnitude-scale I have been able to make, I find the star to have been bright and faint on the following dates.

Bright	M
1894 May 11	7.8
June 1	7.8
July 15	7.8
26	7.9
Aug. 16	7.9
31	7.9
Sept. 6	7.8
Oct. 28	7.9
Nov. 22	7.9
Dec. 22	7.9

Faint	M
1894 May 10	8.2
22	8.3
June 14	8.2
July 14	8.4
24	8.3
30	8.3
Aug. 10	8.3

8116. *W Cephei.*

The observations which resulted in the confirmation of the variability of this star were continued until 1894 February 11, after which time the star was too near the northern horizon for useful observation; they were resumed on May 9, and continued until 1895 January 1, and number in all 138. These have been carefully reduced anew, and yield twenty-one maxima and eighteen minima, as follows:

OBSERVED MAXIMA AND MINIMA.

Local Mean Time

Maxima	W	O—C	Minima	W	O—C
		d			d
1893 Nov. 10.3	3	−0.5	1893 Nov. 18.0	3	−1.8
21.6	4	−1.8	24.3	3	−1.9
Dec. 12.8	2	+0.7	Dec. 1.0	4	−1.7
19.9	4	+0.4	24.1	3	+2.0
28.2	4	−1.3	31.4	3	+2.9
1894 Jan. 12.4	2	−1.0	1894 Jan. 23.0	3	−0.3
27.1	3	+0.8	Feb. 1.0	2	+2.3
Feb. 2.6	4	+0.9	6.2	4	+1.0
9.2	3	+0.8	July 9.4	1	−0.3
July 13.6	4	+0.9	23.0	2	+0.4
24.4	3	−1.2	28.3	4	−0.8
Aug. 6.6	4	−0.9	Aug. 16.7	4	−0.7
13.0	3	−0.9	23.3	4	−0.5
19.7	3	−0.7	29.2	4	−1.1
26.4	3	−0.4	Sept. 20.3	2	+1.7
Sept. 2.0	3	−0.3	Oct. 17.3	2	−1.5
1894 Sept. 10.8	4	+2.1	1894 Oct. 31.3	2	−0.4
23.5	4	+1.9	Nov. 20.3	3	+0.3
Oct. 20.4	4	−1.3			
Nov. 4.4	3	+0.7			
22.3	3	−0.7			

The star's variation seems to be roughly periodic in a period rather shorter than that suggested in my paper on p. 187 of vol. XIII, and the following elements satisfy my observations up to this date tolerably well.

Maximum, 1893 Nov. 10.1 Gr. M.T. $+6^{d}.41\,E$

The residuals in the above table are from comparison with these elements.

The average interval from minimum to maximum is about three days, but while the maxima are in general very definitely marked, the same is not true of the minima.

The irregularities of the observed variation are so great, that I have thought it unadvisable to attempt the formation of a mean light-curve, at any rate until much more material has accumulated. The general character of the variation seems to be that the light-curve is rather flat for a day or more on each side of the minimum phase, with a sharp rise to and decline from the maximum. Two or three of the maxima, however, have been extended over three days or more.

Dorchester, 1895 *March* 4.

OBSERVATIONS OF COMET *e* 1894 (*E. SWIFT*),

MADE WITH THE 26-INCH EQUATORIAL OF THE U.S. NAVAL OBSERVATORY,

BY STIMSON J. BROWN.

[Communicated by Prof. WM. HARKNESS, Astronomical Director.]

The comet was compared directly with some star in the field of the telescope, by measuring with the micrometer-screw differences of right-ascension and declination. The eyepiece employed with a field of about 10′, gave a magnifying power of 190. The comet was generally difficult to observe on account of unfavorable seeing; it was vainly looked for on the nights of January 11, 14 and 20. Stars estimated to be below 15^M were visible on these nights, but the comet could not be seen. The atmospheric conditions during all the month of January were very bad, there being only four nights on which the satellite of *Neptune* could be seen and observed.

OBSERVATIONS OF COMET *e* 1894.

1894 Washington M.T.		*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ	Obsr.
	h m			s	″	h m s	° ′ ″			
Dec. 14	6 31.1	1	6	−11.03	+ 62.7	23 26 5.57	−4 58 41.3	8.895	0.785	B
	6 57.5	1	4	− 8.15	+ 85.6	23 26 8.45	−4 58 18.4	9.123	0.783	B
15	6 28.2	2	4	. . .	−211.2	. . . .	−4 38 43.5	. . .	0.782	B
	6 42.5	2	4	+16.18	. . .	23 28 51.00	. . . .	9.017	. . .	B
	6 54.5	2	4	. . .	−188.3	. . . .	−4 38 20.6	. . .	0.781	B
	7 9.0	3	3	. . .	−239.2	. . . .	−4 37 52.5	. . .	0.780	B
	7 22.0	3	1	0.00	. . .	23 28 55.86	. . . .	9.254	. . .	B&H
17	6 30.4	4	4	+12.29	. . .	23 34 14.92	. . . .	9.088	. . .	B
	6 49.3	4	5	. . .	+346.2	. . . .	−3 57 48.0	. . .	0.796	B
	7 7.4	4	4	+16.67	. . .	23 34 19.30	. . . .	9.283	. . .	B
	7 26.0	1	1	+18.67	. . .	23 34 21.30	. . . .	. . .	. . .	A
	7 34.5	4	2	. . .	+385.4	. . . .	−3 57 8.7	. . .	0.774	A
22	6 50.1	5	4	+ 5.03	. . .	23 47 39.26	. . . .	9.109	. . .	B
	7 8.0	5	5	. . .	+ 61.9	. . . .	−2 17 20.8	. . .	0.762	B
	7 20.1	5	4	+ 8.47	. . .	23 47 42.60	. . . .	. . .	. . .	B
27	6 53.9	6	4	. . .	−110.4	. . . .	−0 40 13.9	. . .	0.748	B&A
	7 21.5	6	9	− 8.02	. . .	0 0 29.43	. . . .	9.214	. . .	B&A

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	23 26 13.62	+2.98	−5 0 1.1	+17.1	Meridian circle, 1 obs.; SDM. −5°6006
2	23 28 31.86	+2.96	−4 35 29.5	+17.2	Equat. comp. with *a*; SDM. −4°5905
3	23 28 52.90	+2.96	−4 34 10.5	+17.2	" " " " SDM. −4°5908
4	23 33 59.63	+3.00	−4 3 51.7	+17.7	Meridian circle, 2 obs.; SDM. −4°5923
5	23 17 31.15	+2.98	−2 18 41.2	+18.5	Equatorial; SDM. −2°6051
6	0 0 51.45	+3.00	−0 38 12.9	+19.4	Equat. comp. with *b*
a	23 26 3.17	. . . .	−4 39 58.5	. . . .	Radcliffe 1890, 6279; SDM. −4°5896
b	0 0 42.16	. . . .	−0 28 6.5	. . . .	Weisse's Bessel, Schjellerup

2 − *a*. $\Delta\alpha = +2^m\ 28^s.69$, $\Delta\delta = +4'\ 29''.0$ 3 − *a*. $\Delta\alpha = +2^m\ 49^s.73$, $\Delta\delta = +5'\ 48''.0$ 6 − *b*. $\Delta\alpha = +0^m\ 12^s.29$, $\Delta\delta = -10'\ 36''.4$

The positions of stars 2 and 3 depend upon chronographic comparisons in right-ascension, and micrometric differences of declination with the 9.6-inch equatorial. The position of 6 depends upon differences of right-ascension and declination measured in steps with the micrometer screw of the 26-inch equatorial.

The observations of December 11, 15, 17 and 22 ought to give good positions of the comet, when the the positions of the comparison-stars are well determined. The stellar nucleus of the comet, although very faint, could be accurately bisected by the micrometer wire. The declinations obtained on the 15th from the first comparison-star are discordant, but the source of the discrepancy can not be found.

The position of Dec. 27 is not entitled to much weight, as the weather was not good, and the comet was only visible at intervals, and then exceedingly faint.

CONFIRMATIONS OF VARIABILITY,

BY HENRY M. PARKHURST.

From the time of the publication of the Supplementary List in June, I watched for (7492) — *Cygni*. I first saw it on Dec. 20. Thirty days later it was still increasing in brightness. But its position for 1855.0, derived from the neighboring star, is R.A. 20h 47m 0s, Decl. +46° 48′.

The new variable in *Hydra*, announced by Mr. SKINNER in no. 332, passed its minimum at about the predicted time, being invisible Jan. 17 and later, and having become easily visible on Feb. 20.

These confirmations permit the following notation.

3425 *X Hydrae*	(1855)	9h 28m 35s	−14° 2′.8
7492 *RZ Cygni*	(1855)	20 47 0	+46 48 .

ED.

NEW ASTRONOMICAL WORK.

Resultate aus den Zonenbeobachtungen am Meridiankreise der Moskauer Sternwarte während der Jahre 1858–1869. *I. Zone* 0° – +4°. *von* H. ROMBERG *und* J. SEYBOTH. St. Petersbourg 1894.

This zone-catalogue of 1121 stars, 8M.0 or brighter, within 4° north of the equator, is the first instalment of an undertaking, begun in 1858 by the late Prof. SCHWEIZER, to observe all stars to the limits of brightness indicated above, in zones 4° broad, going north from the equator. It was continued by him until 1859 Oct., then by BREDICHIN, CHANDRIKOW and SACHAROW until 1863 May, and afterwards by CHANDRIKOW alone until the end of 1869; covering more or less completely four zones, embracing 16° of declination. The zones have been partially published in the Moscow and Kiew Annals. The discussion of the results involved an elaborate investigation of an interesting form of personal systematic error, which was brought to light in the reductions, due to the peculiar method adopted by SCHWEIZER for the declination-pointings. This method consisted in not bringing the star to the middle point between the horizontal threads, 10″ apart, but in estimating its proportional distance from the middle. This method does not seem to have afforded the advantages anticipated. An investigation resting on the interior evidence of the observations themselves, and also upon BOSS's Albany Catalogue, shows that all four observers estimated these distances too small, as well as not proportionally. The discussion of this idiosyncracy constitutes the distinctive and most interesting feature of the introduction.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed March* 15.

THE

ASTRONOMICAL JOURNAL.

No. 341.

VOL. XV. BOSTON, 1895 MARCH 27. NO. 5

PROVISIONAL ELEMENTS OF THE ORBIT OF F.4 *AQUARII* = Σ2729,

By T. J. J. SEE.

This double star was discovered by Sir William Herschel 1782 Sept. 3. He measured the position-angle the following year, and repeated the observations in 1802; by comparing results he was led to conclude that the angular motion since 1783 had amounted to 37°.4 (*Phil. Trans.*, 1804, p. 371). In 1825 Struve measured the star on two nights, and obtained $\theta = 25^\circ.0$, $\rho = 0''.81$; $\theta = 30^\circ.0$, $\rho = 0''.80$ respectively. All the early, and some of the more recent measures of F. 4 *Aquarii* are extremely discordant, and it is very difficult to determine what measures ought to be relied upon. After carefully considering all the measures, it has seemed best to base the orbit on certain selected observations of Sir William Herschel, Struve, Sir John Herschel, Dawes, Secchi, Hall, Burnham, Schiaparelli, and Comstock. Accordingly we find that the position-angle of the companion in 1825 was but little greater than what Struve recorded; but most of Struve's later angles are considerably smaller than they ought to be. Thus, most of the early measures require careful sifting, and the observations of Mädler must be rejected entirely. In comparison with the work of other standard observers, his measures are anomalous and unintelligible. Many years ago Dawes examined the motion of F.4 *Aquarii* (*Mem. R.A.S.*, vol. XXXV, p. 427), and concluded that the distance had diminished, and that the motion had accelerated since Struve's time. Struve supposed that Herschel's measure of 1783 was erroneous, but Dawes arrived at the conclusion that it was Herschel's measure of 1802 that was in error, notwithstanding the fact that the latter was based on two nights' work, while the former was the record of one night only. On examining independently all the observations I have confirmed this conclusion of Dawes, and have therefore taken Herschel's angle of 1783 to be substantially correct. For it is impossible that the angle can have been the same in 1802 as in 1825, when Struve made his measure. We have, therefore, relied on the angle 351°.5 in 1783, 30° in 1825, and Sir John Herschel's angle of 46°.0 in 1832. With this choice of the old observations we experience no great difficulty in dealing with the more recent measures. The resulting elements are believed to be the best that can be obtained from the discordant observations hitherto made, but are still open to considerable uncertainty, and will require further improvement.

Doberck is the only astronomer who has published an orbit for this star. He used most of the observations down to 1877, and obtained the following elements (*A.N.* 2287):

$$P = 129^y.8$$
$$T = 1752.0$$
$$e = 0.46$$
$$a = 0.72$$
$$i = 56^\circ.6$$
$$\Omega = 340^\circ.2$$
$$\lambda = 235^\circ.0$$

Using the method of Klinkerfues we find the following elements of F.4 *Aquarii*:

$$P = 126.65 \text{ years}$$
$$T = 1899.88$$
$$e = 0.543$$
$$a = 0''.7036$$
$$i = 68^\circ.51$$
$$\Omega = 177^\circ.4$$
$$\lambda = 74^\circ.25$$
$$n = +2^\circ.84236$$

Apparent Orbit.

Length of major axis = 1″.196
Length of minor axis = 0″.508
Angle of major axis = 0°.00
Angle of periastron = 229°.8
Distance of star from center = 0″.171

If we examine the accompanying table of computed and observed places, it will be seen that the elements represent the motion fairly well, when Mädler's observations are rejected, and a wide allowance is made for the errors of Herschel and Struve, who had the disadvantage of a high northern latitude. Some of the more recent measures appear to be vitiated by systematic errors in virtue of which the angles are somewhat too large; but the amount of this is small, considering the difficulty of the object, and it may be accidental.

COMPUTED AND OBSERVED PLACES.

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
	°	°	"	"	°	"		
1783.55	351.5	350.4	–	0.46	+ 1.1	–	1	Herschel
1802.65	28.9	11.4	–	0.72	+17.5	–	2	Herschel
1825.60	27.5	33.3	0.80	0.59	– 5.8	+0.21	2	Struve
1830.92	13.4	40.2	0.69	0.54	–26.8	+0.15	1	Struve
1832.73	46.0	43.2	–	0.52	+ 2.8	–	2	Herschel
1832.90	23.0	43.5	Oblonga	0.52	–20.5	–	1	Struve
1833.77	31.2	44.9	0.67	0.51	–13.7	+0.16	1	Struve
1836.05	46.3	48.9	0.41	0.49	– 2.6	–0.08	4	Struve
1839.68	62.2	56.0	–	0.45	+ 6.2	–	2	Dawes
1840.72	65.5	58.2	0.6 ±	0.44	+ 7.3	+0.16	2	Dawes
1841.51	21.6	58.4	0.6 ±	0.44	–23.8	+0.16	1	Mädler
1841.80	72.7	59.1	–	0.44	+13.6	–	1	Dawes
1842.82	27.2	61.4	0.45	0.43	–34.2	+0.02	2–1	Mädler
1843.70	31.9	65.1	0.5 ±	0.42	–33.2	+0.08	3	Mädler
1843.76	81.7	65.2	–	0.42	+16.5	–	1	Dawes
1844.90	23.1	66.9	0.5 ±	0.41	–43.8	+0.09	1	Mädler
1853.70	95.9	93.1	0.5 ±	0.38	+ 2.8	+0.12	1	Dawes
1854.75	101.7	96.3	0.3 ±	0.38	+ 5.4	–0.08	1	Dawes
1855	–	97.0	–	0.38	–	–	–	Secchi
1856.81	107.8	104.5	0.3 ±	0.38	+ 3.3	–0.08	1	Secchi
1862.68	137.5	118.2	Oblonga	0.40	+19.3	–	3	Dembowski
1865.71	125. ±	127.2	Cuneo	0.42	– 2.2	–	1	Secchi
1865.74	143.6	127.3	–	0.42	+16.3	–	1	Talmage
1866.08	139.6	128.3	Oblonga	0.43	+11.3	–	3	Dembowski
1866.65	125.5	130.0	–	0.44	– 4.5	–	3	Searle
1866.66	110.0	130.0	–	0.44	–20.0	–	5	Winlock
1867.86	141.1	133.0	0.30	0.45	+ 8.1	–0.15	1	Newcomb
1872.88	147.5	143.3	Oblonga	0.48	+ 4.2	–	5	Dembowski
1875.62	157.0	148.5	0.4 ±	0.50	+ 8.5	–0.10	4	Schiaparelli
1877.15	148.7	151.3	0.56	0.51	– 2.6	+0.05	3	Dembowski
1877.70	158.5	152.4	0.5 ±	0.51	+ 6.1	–0.01	1	Cincinnati
1879.44	156.4	155.2	0.57	0.52	+ 1.2	–0.05	5–1	Cincinnati
1879.76	155.9	155.8	0.40	0.52	+ 0.1	–0.12	4	Hall
1880.78	165.5	157.5	0.51	0.52	+ 8.0	–0.01	2	Pritchett
1881.54	159.6	158.8	0.52	0.51	+ 0.8	+0.01	3	Burnham
1883.84	182.1	162.0	–	0.51	+20.1	–	1	Seabroke
1884.77	166.8	163.8	–	0.51	+ 3.0	–	7	Seabroke
1885.64	156.1	164.0	–	0.50	– 7.9	–	1	Seabroke
1885.74	167.9	165.8	0.46	0.50	+ 2.1	–0.04	3	Hall
1886.69	162.5	167.4	–	0.49	– 4.9	–	1	Seabroke
1886.74	168.3	167.5	0.54	0.49	+ 0.8	+0.05	3–2	Leavenworth
1886.84	174.8	167.6	0.47	0.49	+ 7.2	–0.02	2	Hall
1887.28	173.4	168.4	0.41	0.49	+ 5.0	–0.08	7	Schiaparelli
1887.79	175.9	169.3	0.53	0.48	+ 6.6	+0.05	3	Hall
1887.82	170.5	169.4	0.52	0.48	+ 1.1	+0.04	2	Tarrant
1888.81	172.4	171.2	0.48 ±	0.47	+ 1.2	+0.01	5	Schiaparelli
1889.51	155.5	172.5	–	0.47	–17.0	–	1	Seabroke
1889.88	176.7	173.2	0.49 ±	0.45	+ 3.5	+0.04	2	Schiaparelli
1891.77	178.1	177.2	0.50 ±	0.42	+ 0.9	+0.08	1	Schiaparelli
1892.80	181.7	179.7	0.33	0.39	+ 2.0	–0.06	2–1	Comstock
1892.91	187.0	179.9	0.4 ±	0.39	+ 7.1	+0.01	1	Schiaparelli
1893.81	182.4	182.5	0.35 ±	0.36	– 0.1	–0.01	2–1	Comstock
1894.86	186.5	186.0	0.38 ±	0.34	+ 0.5	+0.04	3	Schiaparelli

Although the elements of F.4 *Aquarii* here given are only provisional, it is probable that they are a fair approximation to the truth. The list of observations is absolutely complete, and has been made up wholly from original sources. If this orbit is to be relied upon, it is evident that F.4 *Aquarii* will deserve the careful attention of astronomers for some years to come, as the motion will be relatively rapid, and the distance will steadily diminish until about 1900. The following is an ephemeris for the next six years:

t	ϑ	ρ
	°	″
1895.5	187.7	0.32
1896.5	193.0	0.28
1897.5	199.3	0.24
1898.5	208.2	0.20
1899.5	221.4	0.16
1900.5	240.4	0.13

If good measures of this star can be secured for the next ten years, it appears probable that the elements could be well determined.

The University of Chicago, 1895 *March* 1.

OBSERVED MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES, 1894–1895.

By PAUL YENDELL.

678. *U Persei.*

Fourteen observations of *U Persei*, from 1894 Sept. 8 to 1895 Feb. 20, indicate a maximum of $7^{M}.0$, occurring 1895 Jan. 11. The star's brightness when first observed was estimated as $11^{M}.2$. The increase was fairly steady and the maximum well-defined. At the last observation the star's light had decreased to $8^{M}.1$.

845. *R Ceti.*

This star was observed six times, between 1894 Dec. 17, when it was not seen, and was certainly fainter than the tenth magnitude, and 1895 Feb. 11; the curve shown indicates a sharp and rapid rise, a nearly stationary maximum of about twenty days, and a sudden and rapid decrease, the date of maximum indicated being 1895 Feb. 3. The magnitude at maximum was $7^{M}.5$, and when last observed $8^{M}.6$.

906. *R Trianguli.*

Fourteen observations of this star, from 1895 Jan. 14 to March 9, show a maximum of $6^{M}.2$ on 1895 Feb. 14. The light at the first and last observations was $7^{M}.3$.

980. *V Persei.*

I have seventeen observations of this star, from 1894 Sept. 21 to 1895 Feb. 27, its light when first observed was $9^{M}.3$, and the observations show a gradual and steady rise to $8^{M}.8$, with no marked maximum or minimum.

Dorchester, 1895 *March* 11.

1717. *V Tauri.*

Since 1894 Dec. 15 I have observed *V Tauri* seventeen times; at the first observation, it was just held on a very clear sky, and its magnitude was estimated as 12.3. It increased steadily to a faint maximum of $9^{M}.35$, which is indicated on 1895 Feb. 5 by my observations; when last looked for on March 9, it was not seen in bright moonlight on a clear sky, and cannot have been brighter than $10^{M}.0$.

2100. *U Orionis.*

This star was first seen on 1894 Dec. 3, being then below $11^{M}.0$. It rose rapidly until 1895 Feb. 10, when it had reached $6^{M}.9$. A maximum of $6^{M}.7$ was passed on Feb. 21. At the last observation, on March 9, it had declined to $7^{M}.1$. The observations number sixteen.

3170. *S Hydrae.*

I have only five observations of *S Hydrae* at the late maximum, as follows:

	M
1895 Jan. 27	8.4
Feb. 13	7.9
20	8.5
23	8.6
Mar. 3	8.8

Although observations are deficient on the rising branch of the curve, the indications seem to be that the maximum was probably passed about 1895 Feb. 11, and certainly not later than Feb. 13.

OBSERVATIONS OF ENCKE'S COMET,

MADE AT THE CINCINNATI OBSERVATORY,

By PHILLIPS ISHAM.

1894–95 Cincinnati M.T.		*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Dec. 21	8 19 49	1	6	+0 16.39	−9 30.2	22 16 23.46	+4 20 51.6	9.606	0.724
	8 19 49	2	4	−3 45.86	+8 17.8	22 16 23.90	+4 21 7.0	9.606	0.724
25	7 31 3	3	8	+1 1.87	+2 31.0	22 15 30.80	+3 52 51.2	9.568	0.722
31	7 8 0	4	8	−1 39.70	−2 8.4	22 14 2.20	+3 7 8.6	9.569	0.727
Jan. 16	6 25 15	5	8	−0 34.57	+0 49.6	21 59 48.07	−0 49 4.5	9.609	0.748
17	6 42 8	6	8	+0 17.26	−2 27.0	21 57 39.09	−1 17 53.8	9.629	0.749
19	6 21 15	7	8	−0 12.05	−3 17.0	21 52 40.93	−2 23 5.8	9.623	0.753
23	6 37 51	8	9	−0 4.48	−6 25.9	21 38 49.11	−5 19 17.9	9.653	0.753

Mean Places for 1894.0 and 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 16 4.71	+2.36	+4 30 6.3	+15.5	Boss A.G. 7754
2	22 20 7.37	+2.39	+4 12 33.5	+15.7	Boss A.G. 7767
3	22 14 26.59	+2.34	+3 50 5.3	+11.9	11ᴹ. Eq. comp. with Boss A.G. 7747 and 7756
4	22 15 39.57	+2.33	+3 9 2.7	+14.3	Boss A.G. 7752
5	22 0 23.43	−0.79	−0 49 47.6	− 6.5	*α Aquarii — Berl. Jahrbuch*
6	21 57 22.65	−0.82	−1 15 19.9	− 6.9	Gött. 1, 6083–4; Romberg 5014
7	21 52 53.79	−0.81	−2 19 41.5	− 7.3	Munich 1, 29941; 11, 12147
8	21 38 54.39	−0.80	−5 12 43.7	− 8.3	Gould G.C. 29744; Stone 5858

Comparison with the ephemeris in *Astr. Nachr.* 3263, O−C,

	Δα	Δδ		Δα	Δδ
	s	″		s	″
Dec. 21	+0.93	−11.7	Jan. 17	+4.05	+21.2
25	+1.11	− 3.6	19	+4.70	+33.0
31	+2.18	− 3.0	23	+6.20	+39.0
Jan. 16	+4.48	+21.9			

OBSERVATIONS OF SMALL PLANETS,

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY J. H. OGBURN.

1894 Albany M.T.		*	No. comp.	Planet — * Δα	Planet — * Δδ	Planet's Apparent α	Planet's Apparent δ	log pΔ for α	log pΔ for δ
				Antiope (90)					
	h m s			m s	′ ″	h m s	° ′ ″		
Sept. 20	12 28 45	1	6	+3 30.89	−5 47.2	1 3 47.64	+ 3 32 32.0	*n*8.808	0.745
21	11 8 23	2	10	−1 5.26	+2 49.0	1 3 8.70	+ 3 28 30.5	*n*9.356	0.749
25	11 51 5	3	8	−1 12.74	−4 4.8	1 0 15.34	+ 3 10 58.9	*n*8.941	0.748
Oct. 1	11 34 32	4	6	+1 15.33	+0 6.3	0 55 44.47	+ 2 44 23.1	*n*8.864	0.752
21	8 10 17	5	6	+3 11.35	−4 15.6	0 41 5.72	+ 1 24 30.5	*n*9.420	0.766
				Amalthea (113)					
Aug. 22	11 34 53	6	7	+2 5.73	+1 45.2	22 21 31.36	−14 30 1.8	*n*8.900	0.868
26	13 21 58	7	4 , 3	+1 52.22	+0 19.2	22 17 47.51	−14 58 51.0	9.216	0.865
				Cyrene (133)					
July 27	12 10 21	8	6	−1 7.03	−3 14.8	20 33 18.00	−22 3 1.2	6.994	0.902
Aug. 6	11 17 50	9	6	+5 5.03	+1 2.4	20 24 30.75	−22 6 31.7	*n*7.914	0.902
9	12 20 46	9	8	+2 33.87	+1 21.1	20 21 59.59	−22 6 12.9	9.192	0.894
				Josephina (303)					
Sept. 26	9 33 18	10	4	−2 11.35	+6 28.1	0 27 31.03	+ 7 15 12.9	*n*9.428	0.721
28	9 48 23	11	10	+0 18.21	+0 4.2	0 25 53.63	+ 7 9 15.8	*n*9.360	0.718
Oct. 1	10 44 25	12	7	+3 8.45	−6 46.1	0 23 25.90	+ 6 59 56.1	*n*9.022	0.712
6	11 3 27	13	5	−2 44.51	+4 38.9	0 19 25.22	+ 6 43 55.0	*n*8.388	0.713
7	9 58 19	13	5	−3 29.53	+1 33.4	0 18 40.21	+ 6 40 49.6	*n*9.139	0.717
				(331)					
Oct. 27	12 2 38	14	6	−0 31.53	+5 45.9	2 39 55.71	+18 29 37.8	*n*9.349	0.555
28	9 21 10	15	5	+3 53.68	+6 53.4	2 39 8.19	+18 28 0.4	*n*9.487	0.615
29	10 32 28	15	7	+2 57.60	+4 55.0	2 38 12.13	+18 26 2.0	*n*9.253	0.573
Nov. 1	9 38 51	15	9 , 4	+0 17.58	−0 58.6	2 35 32.15	+18 20 8.6	*n*9.395	0.595
2	8 12 15	15	11 , 5	−0 33.21	−2 55.6	2 34 41.38	+18 18 11.8	*n*9.565	0.647
17	7 48 20	16	10 , 4	−0 20.87	+7 26.4	2 21 50.91	+17 43 57.6	*n*9.479	0.624
				1893 *AD* (371)					
Nov. 2	10 37 23	17	8 , 6	+0 23.56	+6 9.8	2 33 39.66	+25 34 21.8	*n*9.140	0.430

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 0 13.39	+3.36	+ 3 37 55.2	+24.0	Albany A.G.Z. 284
2	1 4 10.58	+3.38	+ 3 25 17.3	+21.2	" " 313
3	1 1 24.63	+3.45	+ 3 14 39.2	+24.5	Albany 295, Yarnall 586
4	0 54 25.65	+3.49	+ 2 43 52.3	+24.5	Yarnall, Paris, Albany A.G.Z.
5	0 37 50.77	+3.60	+ 1 28 21.6	+24.5	Paris, Albany A.G.Z.
6	22 19 22.11	+3.52	−14 32 2.1	+15.1	Munich II, 12447
7	22 15 51.70	+3.59	−14 59 25.2	+15.0	Rümker, Munich I
8	20 34 21.48	+3.55	−21 59 51.7	+ 5.3	Argelander, Munich I
9	20 19 22.05	+3.67 +3.67	−22 7 37.8	+ 3.7 + 3.8	Munich II, Yarnall
10	0 29 38.94	+3.44	+ 7 8 21.1	+23.7	Paris 702, Rümker, Gött.
11	0 25 31.98	+3.44	+ 7 8 47.9	+23.7	Albany, 2 observations
12	0 20 14.00	+3.45	+ 7 6 18.5	+23.7	45 *Piscium*
13	0 22 6.24	+3.49 +3.50	+ 6 38 52.0	+24.1 +24.2	Paris 514, Glasgow 116
14	2 40 23.39	+3.85	+18 23 27.6	+24.3	Albany, 2 observations
15	2 35 10.63	+3.88 +3.96	+18 20 42.4	+24.6 +24.9	Armagh II, Romberg
16	2 22 7.76	+4.02	+17 36 5.2	+26.0	Albany, 1 observation
17	2 33 12.05	+4.05	+25 24 47.2	+24.8	Albany, 2 observations

OBSERVATIONS OF ENCKE'S COMET,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1895 Cincinnati M.T.	*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Jan. 16 6 10 3	1	10	−0 33.61	+1 5.9	21 59 49.03	−0 48 48.2	9.593	0.749
17 6 2 5	2	8	+0 21.08	−1 37.4	21 57 42.91	−1 17 4.2	9.590	0.751
19 6 5 25	3	8	−0 10.46	−2 54.7	21 52 42.52	−2 22 43.5	9.609	0.755
22 6 18 25	4	10	+0 12.44	−0 35.3	21 42 51.03	−4 28 33.8	9.638	0.757

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 0 23.43	−0.79	−0 49 47.6	−6.5	*α Aquarii, Berl. Jahrbuch*
2	21 57 22.65	−0.82	−1 15 19.9	−6.9	Gött. I, 6083–4 ; Romberg 5044
3	21 52 53.79	−0.81	−2 19 41.5	−7.3	Munich I, 29941 ; Munich II, 12147
4	21 42 39.39	−0.80	−4 27 50.5	−8.0	Schjellerup 8850

Comparison with the ephemeris in *A.N.* 3263, O−C,

	Δα	Δδ		Δα	Δδ
	s	″		s	″
Jan. 16	+4.05	+20.1	Jan. 19	+4.34	+30.5
17	+3.99	+19.9	22	+5.10	+31.4

PECULIAR ILLUMINATION OF THE MOON DURING THE TOTAL ECLIPSE OF MARCH 10.

[Extract from a Letter of Dr. T. J. J. See to the Editor.]

The total eclipse of the Moon, which was favorably observed here last night, presented a phenomenon so remarkable that I think it worthy of notice. From the time the Moon entered the Earth's shadow until sometime after totality the southern limb of the Moon presented a bright coppery appearance, while the northern portion of the eclipsed disc was quite dark. The red patch covered at least one-third of the Moon's face, and was very conspicuous both in the 4-inch equatorial and to the naked eye. The phenomenon was witnessed by Professor Burnham, who was present, and by several advanced students in astronomy; and after careful examination all agreed that the singular illumination could not be due to any local conditions on the Moon's surface. The red region extended along the southern edge of the Moon's disc, towards the center of the shadow, and therefore almost parallel to the direction of the Moon's motion. It was most conspicuous at about 8h 40m, Central Standard Time, and gradually faded away towards the middle of the eclipse. As the Moon left the shadow, a similar phenomenon was carefully looked for, but not found; the illumination of the two limbs of the Moon appeared symmetrical and of the usual color.

I am not aware of such singular illumination of the disc of an eclipsed Moon being previously noted, and its explanation is therefore not perfectly obvious. It appears most likely to be due to atmospheric conditions along the twilight belt, through which the rays pass that illuminate the Moon during the eclipse. In the present case the belt extended along the eastern part of the Pacific Ocean; and if the equatorial region of this belt should have been clear, while the other portion to the north was heavily laden with clouds, in the one place the light would pass through and produce a ruddy illumination, while in the other it would be cut off and the Moon would appear relatively dark. Whether this explanation be correct or not, I think such singular phenomena are worthy of some attention; it may be that the study of the illumination of the Moon during eclipses might throw some light upon certain phenomena of the Earth's atmosphere.

We noted the instants of contact, although they are of no special importance, as follows:

	h m
First external contact, March 10,	7 54
First internal contact,	8 53
Last internal contact,	10 26
Last external contact,	11 26

Central Standard Time, six hours slow of Greenwich.

The University of Chicago, 1895 *March* 11.

OBSERVATIONS OF ECLIPSE OF MOON, 1895 MARCH 10,

MADE WITH 9½-INCH EQUATORIAL, PRINCETON, N.J.,

BY TAYLOR REED.

Clouds were exceedingly troublesome, permitting observations only at intervals.

At 11h 30m Gr. M.T. the illumination of the whole obscured part of the Moon's disc was very evident.

At 11h 35m it was noticed that this illumination was uneven.

During totality the illumination was strong and uneven. In the latter half of totality in particular the edge of the disc appeared brighter than the center, except 60° or so at the western side. Little of the usual red color was detected.

Soon after totality Moon was entirely hidden by clouds. Only two occultations were well observed.

	DM. +3°2514 Emersion h m s	Albany 4305 =DM+3°2519 Immersion h m s
Princeton Sid. T. (Chronogr.)	10 42 3.8	10 43 45.2
Greenwich M.T.	16 26 21.1	16 28 2.2
Observation estimated late	0s.5	0s.1

Observed with micrometer, and magnifying power 155.

LUNAR ECLIPSE OF 1895 MARCH 10,

BY MARY W. WHITNEY.

The total lunar eclipse of March 10 was observed at Vassar College under more favorable conditions than appear to have prevailed in many other places, according to newspaper reports. There were shifting clouds during the evening, but they did not seriously obscure the sky until after third contact. The Dorpat circular did not reach Poughkeepsie until the Monday following the eclipse, but we observed four occultations, three of which are included in the Dorpat list. They are as follows:

	Immersion h m s	
Albany Zone 4297	15 7 50.38	G.M.T.
DM. 3°2514	15 47 31.54	"
Albany Zone 4302	16 22 13.51	G.M.T.
" " 4305	16 29 51.08	"

The first three contacts were observed with the usual unsatisfactory results. Four of my students joined in these observations, using glasses ranging from three inches to five inches. The means of all our times are as follows:

	Greenw. M.T. h m s	
1st contact	13 55 23.7	5 observers (of course too late)
2d contact	14 52 8.9	5 "
3d contact	16 24 31.9	1 "

OBSERVATIONS OF THE TOTAL ECLIPSE OF 1895 MARCH 10, AT THE WASHBURN OBSERVATORY,

BY GEORGE C. COMSTOCK.

The eclipse was observed in a perfectly clear sky at this observatory and was noteworthy for the unusual brightness of the moon during totality.

The request for observations of occultations during totality and the predicted times of immersion and emersion prepared by W. DÖLLEN, were not received here until after the eclipse and no especial effort to secure such observations was made. Mr. A. S. FLINT, however, observed with the six-inch Clark equatorial, with a magnifying power of 125, the immersions of two stars subsequently identified as Nos. 15 and 16 of DÖLLEN's list; Albany Zones, 4302, 4305. The local sidereal times and the resulting Greenwich mean solar times of disappearance are:

	h m s		h m s	
No. 4302	9 16 8.9	Local.	15 59 31.0	Greenwich.
4305	9 20 3.2		16 3 24.6	

The observer notes that the moon's limb was inconveniently bright. The observations were made by eye and ear, and the clock correction upon which the sidereal times depend was determined immediately preceding the observations.

My own attention was directed to an attempt at measuring the density of the lunar atmosphere by the displacement of stars at the instant of their disappearance behind the moon's limb. It is well known that the irregularities of the moon's limb combined with an imperfect knowledge of its semi-diameter, seriously impair for this purpose the value of observed times of occultations. To avoid these difficulties, I purposed measuring with the filar micrometer of the large equatorial, aperture 40*cm.*, the relative position of neighboring stars at the instant of occultation of one of these bodies and also at some convenient instant, *e.g.* five minutes before occultation, when their relative position might be assumed free from the effect of any refraction in the lunar atmosphere.

During totality seven observations of this kind were secured, of which, five indicate a displacement in the direction corresponding to the refractive effect of a lunar atmosphere, and two a displacement in the opposite direction. The mean value of the observed displacement is 0″.6, the individual results ranging from +2″ to −2″, but these results can not be considered as indicating much beyond the fact that a filar micrometer is not well adapted to observations of this character. With a double-image micrometer I believe that better results may be obtained, and I hope to undertake future observations of this kind.

Madison, 1895 *March* 18.

OBSERVATIONS OF VARIABLE STARS OF SHORT PERIOD DURING THE YEAR 1894,

BY PAUL S. YENDELL.

5952. *Y Herculis.*

Observations of *Y Herculis* made during the season of 1894, show one maximum and one minimum, viz.:

	w		w
Maximum, 1894 May 27.4	3	Minimum, June 3.3	2

6368. *X Sagittarii.*

Six maxima and three minima, as follows:

Maxima	w	Minima	w
1894 May 29.28	2	1894 July 29.94	2
June 21.09	2	Aug. 6.22	3
July 12.45	2	19.13	2
Aug. 1.81	2		
7.50	2		
16.44	2		

6472. *W Sagittarii.*

Three maxima and three minima, as follows:

Maxima	w	Minima	w
1894 July 8.95	3	1894 June 20.17	2
31.37	3	Aug. 5.17	2
Aug. 6.89	3	18.89	2

6573. *Y Sagittarii.*

Four maxima and two minima, as follows:

Maxima	w	Minima	w
1894 May 8.96	3	1894 June 21.92	2
July 11.32	3	July 3.18	3
Aug. 3.53	3		
8.77	3		

6636. *U Sagittarii.*

Four maxima and five minima:

Maxima	w	Minima	w
1894 May 9.98	2	1894 May 19.04	2
July 9.58	2	July 2.54	2
29.71	2	Aug. 2.96	2
Aug. 5.42	2	16.45	2
		23.32	1

6758. *β Lyrae.*

Two minima, viz.:

	w
1894 May 15.502	3
June 20.653	3

6984. *U Aquilae.*

Eight maxima and three minima, as follows:

Maxima	w	Minima	w
1894 May 10.60	2	1894 June 4.37	2
31.21	3	July 30.38	4
July 5.72	3	Aug. 27.90	2
26.26	4		
Aug. 23.12	2		
Sept. 6.88	2		
20.59	3		
27.30	2		

7149. *S Sagittae.*

The observations of this star show six minima, as follows:

	w
1894 May 3.57	1
29.78	4
June 22.11	2
July 9.50	2
26.00	4
Nov. 4.32	3

The only two maxima shown by the single light-curve, July 29.6 and Aug. 7.7, seem to bear out SAWYER's suggestion of alternating curves, the first being flat at the maximum, and about a step fainter than the second, which is sharply defined.

7437. *X Cygni.*

Three maxima and four minima, as follows:

Maxima	w	Minima	w
1894 May 27.0	3	1894 July 10.0	3
Aug. 1.6	4	Aug. 10.0	4
17.7	4	26.6	3
		Oct. 31.6	4

Collecting the scattered observations, 17 in number, and forming graphically a normal maximum, it is found to show a residual of $-0^{d}.3$, corresponding to the epoch 175.

Dorchester, Mass., 1895 *March* 9.

7483. *T Vulpeculae.*

Fourteen maxima and thirteen minima, as follows:

Maxima	w	Minima	w
1894 May 9.65	3	1894 May 3.57	2
27.26	3	30.95	2
June 4.77	2	June 3.16	3
July 10.61	2	21.40	2
23.51	3	July 9.41	2
28.22	2	27.00	3
Aug. 1.36	2	Aug. 17.83	3
6.39	3	22.39	2
10.50	3	Sept. 22.87	3
15.56	2	27.33	2
Sept. 6.18	2	Oct. 27.90	2
23.53	3	Nov. 5.71	2
Nov. 2.62	2	28.30	1
Dec. 3.77	3		

I wish to call attention to a clerical error occurring in my paper on 103 *T Andromedae*, published in no. 335 of this Journal. On page 184 the first date in the column headed "Computed Time—Yendell," should read "1855 Sept. 10.0," instead of "1855 Oct. 10.0."

NEW ASTEROIDS.

Two small planets, probably new, were found by Prof. WOLF of Heidelberg, on his photographic plates of Feb. 23, in the positions.

BP $12\frac{1}{2}^{\mathrm{M}}$ Feb. 23 $10^{h}\ 18^{m}$ Heidelb. M.T. $\alpha = 11^{h}\ 0^{m}.5$, $\delta = +9^{\circ}\ 8'$. Daily motion, -66^{s} in α, and $0'.5$ northward.
BQ 13^{M} Feb. 23 10 18 " " $\alpha = 10\ 41.9$, $\delta = +5\ 58$. Daily motion, -60^{s} in α, and $0'$ in declination.

Two others were found on plates of Feb. 25, and announced as *BR* and *BS*; but Mr. BERBERICH has found these to be (379) and (333) *Badenia*, respectively.

CORRECTION TO OBSERVED POSITION OF (175) *ANDROMACHE.*

NOTE FROM MR. ISHAM.

In my observations of small planets published in *A.J.* no. 339 (pp. 22, 23), the place of the star no. 7 was incorrectly reduced. That place should be as follows:

*	α	Red.	δ	Red.	
7	$22^{h}\ 32^{m}\ 15^{s}.26$	$+3^{s}.27$	$-13^{\circ}\ 55'\ 11''.6$	$+15''.3$	Bonn VI, Munich I

With this position of the comparison-star, the place of the planet is as follows:

175 *Andromache.*

	Cincin. M.T.	App. α	App. δ
Aug. 6	$10^{h}\ 52^{m}\ 52^{s}$	$22^{h}\ 32^{m}\ 49^{s}.15$	$-13^{\circ}\ 51'\ 46''.7$

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed March* 25.

THE

ASTRONOMICAL JOURNAL.

No. 342.

VOL. XV. BOSTON, 1895 APRIL 9. NO. 6

OBSERVATIONS OF THE DIAMETER OF *NEPTUNE* AND OF THE POSITION OF HIS SATELLITE,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY,

By E. E. BARNARD.

Recognizing the need of observations of the satellite of *Neptune* and of those of *Uranus*, I took up the measurement of these bodies at my first opportunity with the 36-inch.

A series of measures of all four satellites of *Uranus* were secured in 1894. These will soon be published.

Measures of the positions of the satellite of *Neptune* were secured during the oppositions of 1892–3, 1893–4, and were published in *A.J.* 290 and 314.

The present measures of 1894–5 of this satellite are a continuation of the previous work. Much bad weather during the winter prevented many observations. The measures are, however, pretty well distributed about the orbit.

A magnifying power of 520 was used, except when otherwise noted. On a couple of nights 1000 diameters was used. I think, however, that more satisfactory results can be obtained with the lower power, since the eye then more readily takes in the planet and the satellite, and the effect of the wind is less perceptible.

During these observations, I decided to measure the diameter of *Neptune*, in conformity with my scheme to measure the diameters of all the planets and asteroids measurable with the great telescope.

For the measures of the diameters of the planets whose discs are small, I have selected a magnifying power of 1000 diameters. This power is sufficiently high to show the discs well, at the same time that the seeing will more often permit its use, than would be the case with the still higher powers. The measures of the diameter of *Neptune* have been made with this eyepiece. Unless the seeing is fairly good it would be folly to measure an object of this kind because its disc would not be seen. Therefore but ten nights' measures could be obtained of the diameter of *Neptune*. In nearly every instance the disc was fairly well seen, though often the planet was difficult to measure from the oscillation of the image.

As in all my measures of the diameters of the planets, I have found it unadvisable to attempt to make the inner or outer edges of the threads tangent to the disc of the planet, and then correct for their thickness. This is a nicety that is impracticable with the usual unsteady image. The threads are about 0″.13 in thickness. With this small diameter of thread it is easier to bisect the limb of the planet with the center of the thread, and more certain than to make the edge of the thread tangent to the limb. If the image were perfectly steady there might be some chance of following the latter method — but this essentially never happens.

During these observations, the disc of *Neptune* has always appeared to be round, except in a single case, while in the observations of *Uranus* the disc was always decidedly elliptical — and this was readily shown by the measures.

Following are the measures of diameter.

MEASURES OF THE DIAMETER OF *Neptune* WITH THE 36-INCH EQUATORIAL.

	Obsd.	Δ	δ
	″	″	″
1894 Nov. 18	2.47	2.38	+0.05
19	2.47	2.38	+0.05
Dec. 31	2.55	2.46	−0.03
1895 Jan. 6	2.62	2.54	−0.11
Feb. 5	2.37	2.31	+0.12
17	2.61	2.57	−0.14
18	2.29	2.25	+0.18
24	2.46	2.43	0.00
25	2.54	2.52	−0.09
Mar. 4	2.50	2.49	−0.06
Mean		2.433	

The column Δ contains the measures reduced to the mean distance of *Neptune* from the sun = 30.0551; and δ is the deviation from the mean. The above measures are double distances.

This determination of the diameter of *Neptune* would correspond to an actual diameter of 32900 miles.

From HOUZEAU's *Vade Mecum* the following previous measures of the diameter of *Neptune* are derived.

		″
1846	Laugier (bi-refrangent mic.)	2.60
1846	Main (double-image mic.)	4.36
1847	Hind	2.47
1847	Challis	2.99
1847	Madler	2.40
1853	Lassell	2.71
1867	Lassell and Marth	2.24
1872	Kaiser	2.87
Mean (omitting Main's measures)		2.611

The latest measures of the diameter of *Neptune* that I know of is a series made by HERMANN STRUVE with the 30-inch of Pulkowa. There were three sets of measures, with different kinds of illumination of the field. These are (see notice in *A.J.* 321)

	″	
Yellow field	2.120	5 obs.
Bright red field	2.197	10 "
Dark field	2.273	10 "
Mean	2.197	

The following measures of the position of the satellite are referred to the center of the disc of *Neptune*.

As in the previous measures of this satellite, I have given the *circle-setting* for the threads at the times of the distance measures. This is not the position-angle.

The observations throughout are in Standard Pacific Time, which is $8^h\,0^m$ slow of Greenwich.

As usual, all the measures (including those of diameter) were made with a dark field.

POSITIONS OF SATELLITE OF *Neptune*.

1894 *November* 18.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
15 12 44	37.6	40.9	Parallel = 266°.7
14 58	36.8	40.1	
16 8	36.2	39.5	
17 23	36.4	39.7	

Distance from Center of *Neptune*.

h m s	r	″	
15 19 42	94.250	14.36	Coincidence of threads = 95r.700
20 50	94.251	14.35	
22 8	94.253	14.33	

Setting of circle for the distances = 126 .4.

Threads reversed.

h m s	r	″
15 23 34	97.115	14.01
24 35	97.124	14.10
25 58	97.128	14.14

November 19.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
14 33 48	135.8	319.2	Parallel = 266°.6
35 43	135.6	319.0	
36 56	135.7	319.1	
38 16	135.4	318.8	

Distance from Center of *Neptune*.

h m s	r	″	
14 40 13	94.660	10.31	Coincidence = 95r.701
41 31	94.681	10.10	
42 26	94.682	10.09	

Thread reversed.

h m s	r	″
14 43 33	96.726	10.45
46 53	96.741	10.00
48 21	96.740	10.29

Setting for the distances = 225°.4.

"Am not sure the planet is not slightly elongated in the direction of P.A. 80°" (1000 diameters at measures for diameter of *Neptune*).

December 23.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
9 20 43	86.8	60.0	Parallel = 116°.8
23 58	86.7	59.9	
26 3	87.4	60.6	
27 18	86.7	59.9	

Distance from Center of *Neptune*.

h m s	r	″	
9 32 15	94.223	16.05	Coincidence = 95r.844
33 39	94.197	16.31	
35 3	94.039	17.88	

Setting for the distances = 177°.0.

Threads reversed.

h m s	r	″
9 37 3	97.572	17.41
38 18	97.476	16.16
39 38	97.611	17.50

Satellite very faint. Thick frost on object-glass. Observations difficult.

December 31.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
10 42 19	295.7	268.8	Parallel = 296°.9
43 34	297.2	270.3	
44 41	296.1	269.2	
45 46	296.6	269.7	

Distance from Center of *Neptune*.

h m s	r	″	
10 48 8	94.375	14.45	Coincidence = 95r.834
49 24	94.391	14.29	
50 6	94.393	14.27	

Threads reversed.

h m s	r	″
10 53 0	97.345	14.96
54 14	97.286	14.38
55 44	97.341	14.92

Setting for the distances = 26°.0.

Satellite faint, but observations good. Perhaps frost on object-glass.

1895 *January* 6.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
8 57 29	113.3	266.5	Parallel = 296°.8
59 7	114.3	267.5	
59 59	114.5	267.7	
9 1 14	113.3	266.5	

Distance from Center of *Neptune*.

h m s	r	″	
9 3 9	97.351	14.96	Coincidence = 95r.840
4 4	97.404	15.49	
4 52	97.367	15.12	

Threads reversed.

h m s	r	″
9 6 12	94.370	14.56
7 17	94.375	14.54
8 15	94.365	14.61

Setting for the distances = 204°.0.

Frost on object-glass, and satellite very faint.

January 28.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
9 16 58	38.8	27.1	Parallel = 101°.6
18 39	38.9	27.2	
19 33	39.9	28.2	
20 28	40.3	28.6	

Distance from Center of *Neptune.*

h m s	r	″	
9 22 48	97.132	12.77	Coincidence = $95^{\mathrm{r}}.843$
23 53	97.120	12.65	
25 3	97.095	12.40	

Setting for the distances = 129°.0.

Threads reversed.

h m s	r	″
9 26 0	94.582	12.49
26 52	94.600	12.31
27 38	94.569	12.62

Wind shaking telescope badly.

February 4.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
6 50 22	128.6	297.3	Parallel = 101°.3
52 17	128.0	296.7	
53 35	128.4	297.1	
56 55	128.8	297.5	

Distance from Center of *Neptune.*

h m s	r	″	
7 2 2	96.994	10.82	Coincidence = $95^{\mathrm{r}}.901$
3 44	97.028	11.16	
4 42	97.025	11.13	

Threads reversed.

h m s	r	″
7 5 54	94.757	11.33
7 14	94.810	10.80
8 16	94.771	11.19

Setting for the distances = 218°.6.

Satellite faint from moon shining on object-glass.

February 5.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
7 15 24	256.3	245.0	Parallel = 281°.3
17 4	256.2	244.9	
18 7	256.2	244 9	
18 54	255.8	244.5	

Distance from Center of *Neptune.*

h m s	r	″	
7 22 2	94.243	16.44	Coincidence = $95^{\mathrm{r}}.903$
23 32	94.233	16.54	
24 51	94.232	16.55	

Threads reversed.

h m s	r	″
7 26 37	97.573	16.54
28 14	97.595	16.76
29 40	97.572	16.53

Setting for the distances = 346°.0.

February 17.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
8 28 47	269.4	234.3	Parallel = 125°.1
30 39	268.3	233.2	
31 14	269.1	234.0	
32 57	270.8	235.7	

Distance from Center of *Neptune.*

h m s	r	″	
8 36 7	94.319	16.39	Coincidence = $95^{\mathrm{r}}.974$
37 34	94.379	15.80	
39 32	94.373	15.86	

Threads reversed.

h m s	r	″
8 40 42	97.675	16.84
41 57	97.580	15.90
44 22	97.665	16.74

Setting for the distances = 360°.0.

Wind shaking telescope badly. Seeing very poor.

February 18.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
8 28 1	213.3	178.1	Parallel = 305°.2
31 41	214.5	179.3	
32 46	214.7	179.5	
33 21	213.0	177.8	

(Observations interrupted)

9 23 26	209.5	174.3

Distance from Center of *Neptune.*

h m s	r	″	
9 26 55	95.012	9.56	Coincidence = $95^{\mathrm{r}}.977$
28 7	94.985	9.82	
29 5	94.978	9.89	

Threads reversed.

h m s	r	″
9 30 0	96.980	9.93
30 50	97.007	10.20
31 50	97.010	10.23

Setting for the distances = 299°.5.

Satellite unusually faint. Sky good. Seeing fair.

February 24.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
7 42 27	206.1	170.9	Parallel = 125°.2
43 49	206.3	171.1	
45 43	204.7	169.5	
48 42	205.5	170.3	
52 32	204.1	168.9	

Distance from Center of *Neptune.*

h m s	r	″	
7 58 2	96.967	9.85	Coincidence = $95^{\mathrm{r}}.972$
58 28	97.025	10.43	
8 0 43	96.961	9.79	

Threads reversed.

h m s	r	″
8 1 40	95.005	9.57
2 41	95.039	9.24
3 12	94.976	9.86

Setting for the distances = 295°.0.

Fog flying over the mountain. Satellite difficult at the measures for position-angle. Better seen at the distance.

February 25.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
7 3 44	123.9	88.7	Parallel = 305°.2
7 54	122.0	86.8	
9 14	122.5	87.3	
10 37	123.7	88.5	

Distance from Center of *Neptune.*

h m s	r	″	
7 13 34	97.485	14.98	Coincidence = $95^{\mathrm{r}}.972$
14 39	97.420	14.34	
15 44	97.430	14.44	

Threads reversed.

h m s	r	″
7 16 59	94.572	13.86
18 49	94.562	13.96
20 1	94.602	13.57

Setting for the distances = 213°.0.
Seeing poor.

March 3.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
7 22 1	249.9	83.6	Parallel = 256°.3
24 56	248.8	82.5	
27 34	249.5	83.2	
35 29	248.3	82.0	

Distance from Center of *Neptune*.

h m s	r	″	
7 39 20	94.391	15.69	Coincidence = $95^r.975$
41 9	94.521	14.40	
42 40	94.473	14.87	

Threads reversed.

h m s	r	″
7 44 36	97.551	15.64
46 29	97.557	15.67
48 4	97.525	15.35

Setting for the distances = 159°.0.

Measures with 1000 diameters. Sky very thick, and satellite very faint.

Mt. Hamilton, Cal., 1895 *March* 15.

March 4.

Stand. Pac. T.	Circle	Pos. Angle	
h m s	°	°	
7 30 33	31.6	45.4	Parallel = 256°.2
32 18	30.6	44.4	
33 16	30.9	44.7	
34 31	31.3	45.4	

Distance from Center of *Neptune*.

h m s	r	″	
7 36 31	97.482	14.94	Coincidence = $95^r.973$
37 46	97.482	14.94	
38 51	97.501	15.43	

Threads reversed.

h m s	r	″
7 39 59	94.432	15.26
41 33	94.495	14.64
42 23	94.441	15.17

Setting for the distances = 121 .0.

Measures with 1000 diameters. Image steady.

MERIDIAN OBSERVATIONS OF *ALGOL* AND OTHER STARS,

By LEWIS BOSS.

Recent hypotheses and researches as to the motion of *Algol* (*A.J.* XI, pp. 113, 121; *Ann. H.C.O.* XXIX; *A.J.* XIV, p. 41; *V.J.S.* XXIX, p. 196, etc.) seem of interest sufficient to warrant further observation of that star. It appeared probable, also, that such observations at this time with the Olcott Meridian Circle, at Albany, might prove instructive in relation to the proper use of that instrument, and the final preparation of it for regular work. Since the proposed observations of *Algol* would be differential in a very strict sense, the observed position of that star ought not to be materially influenced by the neglect of refinements in instrumental correction, so far as such corrections can be formulated in expressions not abruptly variable with time and zenith-distance.

The plan was to observe *Algol* twice in each position of the two circles, or four times clamp E, and as many clamp W, — referring the position of the instrument, on each night, exclusively to the star places of the *Berliner Jahrbuch*; and deriving the clock-correction and equator-reading of the circles on each night, from as many as practicable of the thirteen comparison-stars selected by Dr. CHANDLER (*A.J.* XI, p. 114) and adopting for these the mean places given in the *B.J.* for 1895.0.

Experience seemed to indicate that the hourly rate of the clock derived from comparison of determinations made upon the successive dates, would consistently apply to the observations of each night with substantially the same probability of real accuracy and applicability that would attach to the best determination of that rate from the results for separate stars on any given night. There is evidence that changes in other constants of reduction might have been sensible on some of the nights, but such changes appeared to be always small, and not certainly predicable from the observations themselves; therefore the values of c and n in R.A. and of the equator-reading in declination were assumed to be invariable during the period of observation on each night; and for the clock-correction, Δt, was substituted $\Delta t + m$. The value of n (in n tang δ) was derived from one or more (usually two) of the stars, *α Urs. Min.*, 750 Groombridge, and *δ Urs. Min.* L.C., in combination with south stars.

The following table exhibits (less one decimal place) the adopted values of the transit-constants of reduction on each night, at an epoch differing but little from 3^h sidereal time on each night, except Feb. 12 ($2^h\,12^m$).

	Pos.	$\Delta t + m$	Hour rate	n	b	c	Ther. C.
		s	s	s	s	s	°
Jan. 24	E	+ 6.49	+0.028	+0.14	+0.38	−0.02	− 9
25	E	+ 7.16	+0.025	+0.20	+0.23	−0.02	− 6
27	E	+ 8.31	+0.027	+0.25	+0.39	−0.02	− 8
29	E	+ 9.71	+0.027	+0.34	+0.41	−0.02	− 9
Jan. 31	W	+10.90	+0.025	+0.32	+0.40	−0.01	−10
Feb. 12	W	+18.55		+0.45	+0.38	0.00	− 4
14	W	+19.69	+0.030	+0.24	+0.34	0.00	− 3
15	W	+20.46	+0.029	+0.19	+0.34	0.00	− 3
16	W	+21.06	+0.025	+0.21	+0.31	0.00	− 3

The period between Feb. 2 and Feb. 10 was one of storms and extremely low temperatures.

From the methods employed it becomes evidently allowable to compute the observed (differential) place of each one of the comparison-stars by omitting each one in turn from the determination of $\Delta t + m$ and equator-reading, making its place depend upon those for the remaining 12 comparison-stars. The separate results, thus derived, and in the form of corrections to *B.J.* 1895.0, are exhibited in the following table.

OBSERVED CORRECTIONS FOR STAR-PLACES IN THE BERLINER JAHRBUCH, 1895.0.

Date 1895	Pos.	*γ Andromedae* $\Delta\alpha$	$\Delta\delta$	*β Trianguli* $\Delta\alpha$	$\Delta\delta$	*θ Persei* $\Delta\alpha$	$\Delta\delta$	F.41 *Arietis* $\Delta\alpha$	$\Delta\delta$	*γ Persei* $\Delta\alpha$	$\Delta\delta$	*ρ Persei* $\Delta\alpha$	$\Delta\delta$	*β Persei* $\Delta\alpha$	$\Delta\delta$
		s	″	s	″	s	″	s	″	s	″	s	″	s	″
Jan. 24	AE	−0.011	+0.12	−0.019	−0.24	+0.101	. .	+0.046	+0.43	−0.033	+0.54	. .	. .	−0.029	−0.92
25	AE	+0.041*	−0.29	−0.040	−0.93	−0.034	−0.27	+0.039	−1·00	. .	. .	−0.009	+0.10	−0.035†	+1.11
Jan. 27	BE	−0 024	+0.22	−0.024	+0.76	+0.012	+0 28	+0.014	+0.22	. .	. .	+0.037	−1.90	+0.032	−0.86
29	BE	−0.030	+0.46	−0.082	+0.96	−0.059	+0.04	+0.040	0.00	−0.011	+0.30	. .	. .	−0.038	−0.04
Jan. 31	AW	+0.051*	−0.23	−0.022	+0.42	+0.080	−0.40	+0.002	−1.75	−0.053	−0.83	. .	. .	+0.079*	+0.69
Feb. 14	AW	+0.031	−0.51	+0.051	−0.70	. .	. .	+0.062	+0.88	. .	. .	+0.018	+0.38	+0.044	−0.02
Feb. 15	BW	+0.115*	+1.29	−0.008	+1.02	+0.043	−0.51	+0.018	+0.14	. .	. .	−0.018	+0.60	+0.070	+0.72
16	BW	−0.017	−1.08	−0.021	+0.09	+0.027	+1.48	. .	. .	−0 014	−0.98	. .	. .	+0.062*	+0.47
Means		+0.020	0.00	−0.021	+0.17	+0.024	+0.10	+0.036	−0.15	−0.028	−0.24	+0.007	−0.21	+0.023	+0.07

Date 1895	Pos.	*α Persei* $\Delta\alpha$	$\Delta\delta$	*δ Persei* $\Delta\alpha$	$\Delta\delta$	*ν Persei* $\Delta\alpha$	$\Delta\delta$	*η Tauri* $\Delta\alpha$	$\Delta\delta$	*ζ Persei* $\Delta\alpha$	$\Delta\delta$	*ε Persei* $\Delta\alpha$	$\Delta\delta$	*ξ Persei* $\Delta\alpha$	$\Delta\delta$
		s	″	s	″	s	″	s	″	s	″	s	″	s	″
Jan. 24	AE	−0 004	+0.16	+0 017	−0.87	. .	. .	+0 011	−0.49	−0.042	−0.27	. .	. .	−0 073	+0.62
25	AE	−0.063	−0.69	+0.007	+1.11	. .	. .	+0.032	+0.14	+0.019	+1.06	. .	. .	+0 019	+0.67
Jan. 27	BE	−0.051	−0.92	+0.090	+0.34	−0.007*	+0.87	. .	. .	−0.037	+0.04	. .	. .	−0 041	+0.12
29	BE	−0.031	−0.22	. .	. .	−0.044*	+0.58	+0.058	+0.32	. .	. .	+0.139*	−1.91	+0.019	−0.56
Jan. 31	AW	−0.062	−0.07	+0.003	−0.24	+0.061*	+1.20	. .	. .	−0.041	+0.28	.	. .	−0.020	+1.59
Feb. 14	AW	−0.067	−0.23	−0.068	−0.36	. .	. .	+0 030	+0.60	−0.028	−0.09	−0.038	+0.06	. .	. .
Feb. 15	BW	−0.030	−1.18	−0.079	−0.99	−0 053*	+0.14	. .	. .	+0.026	−0.41	. .	. .	−0.015	−0.06
16	BW	+0.041	+1.43	. .	. .	−0.014*	−1.24	+0 038	−0.44	. .	. .	−0.043	+0.75	. .	. .
Means		−0.033	−0.22	−0.005	−0.17	−0.011	+0.31	+0.034	−0.03	−0.017	+0.10	+0.019	−0.37	−0.019	+0 40

* The values of $\Delta\alpha$ distinguished by an asterisk result from transits of stars which would regularly be observed as south stars, feet to the south, but which were actually observed, "feet north."

† The transit of *β Persei* on Jan. 25 depends on only three threads; the effect of this may be roughly considered as increasing the probable error of the R.A. on that date from ±0s.030 to about ±0s.040. With a weight of ½ for Jan. 25, the mean $\Delta\alpha$ for *β Persei* becomes +0s.027.

The probable error for one observation appears to be about ±0s.032 for R.A. and ±0″.50 for Decl. I am convinced that better results, both in R.A. and Decl., as to accidental error, might have been obtained through a more free use of the zenith-distance micrometer, in the use of which at low temperatures a degree of distrust was felt (as to its action) which further study indicates not to have been warranted. The tangent screw could not be used with advantage for zenith-distances less than 10°; for such stars the setting upon slightly inclined wires was effected by tapping the telescope with the hand, a process which I cannot recommend, on account of the confusion sometimes introduced, and also on account of the distraction from the transit-work. For F.41 *Arietis*, *γ Persei*, *η Tauri* and *ζ Persei* the tangent motion could be, and was, used, as customary in observations with this instrument, with evidently much greater precision in the sense of accidental error.

During these observations the pivots were allowed to rest on their bearings with a residual pressure of 8 kilograms for each. It appears quite certain now that for this instrument the pressure on the pivot bearings should be at least 12 kilograms, when the temperatures are low, unless all traces of oil are removed from the pivots.

These and other similar drawbacks to accuracy probably have not introduced any marked source of systematic error in these differential observations.

The right-ascension determinations do not indicate systematic error dependent on declination, or otherwise, between the results obtained in the respective positions W and E. Means of groups formed at +8°, +34° and +47° of declination show the mean values of W−E less than 0s.01 in every instance.

But when the means for the two positions are compared with the right-ascensions of the *B.J.*, a slight dependence of the differences upon declination is indicated. The following table exhibits this, also shows the corresponding comparison for declination, and in the last column presents the corrections to *B.J.* right-ascensions, found by Dr. CHANDLER (see *A.J.* IX, p. 124 and *H.C.O. Ann.* XXIX, p. 222).

		Albany −*B.J.*				Ch. −*B.J.*
	Mean δ	$\Delta\alpha$	Obs.	$\Delta\delta$	Obs.	$\Delta\alpha$
	°	s		″		s
−20° to +22°	+ 8.2	+0.024	23	. . .	. .	. . .
η Tauri	+23.8	+0.034	5	−0.03	5	+0.021
F.41 *Arietis*	+26.8	+0.036	7	−0.15	7	+0.005
ζ Persei	+31.6	−0.017	6	+0.10	6	0.000
β Trianguli	+34.5	−0.021	8	+0.17	8	−0.026
ξ Persei	+35.5	−0.019	6	+0.40	6	+0.007
ρ Persei	+38.4	+0.007	4	−0.21	4	+0.005
ε Persei	+39.7	+0.019	3	−0.37	3	+0.004
β Persei	+40.6	+0.023	8	+0.07	8	+0.077
γ Androm.	+41.8	+0.020	8	0.00	8	+0.007
ν Persei	+42.2	−0.011	5	+0.31	5	−0.041
δ Persei	+47.5	−0.005	6	−0.17	6	−0.018
θ Persei	+48.8	+0.024	7	+0.13	6	+0.017
α Persei	+49.5	−0.033	8	−0.22	8	+0.018
γ Persei	+53.1	−0.028	4	−0.24	4	−0.021

Personal equation depending upon declination (rate of star's apparent diurnal motion), irregularities of pivot which do not affect the differences, W—E. or error of the *B.J.* system, which is now affected with about minus one-third the systematic error of BRADLEY's right-ascensions, are among explanations which might be offered to account for these small differences in right-ascension, should they prove to be real.

The resulting observed positions of β *Persei* and of the 13 comparison-stars for 1895.0 are appended.

CONCLUDED POSITIONS FOR 1895.0.

	R.A.	No. Obs.	Decl.	No. Obs.
	h m s		° ′ ″	
γ *Andromedae*	1 57 27.161	8	+11 49 32.54	8
β *Trianguli*	2 3 17.671	8	+34 29 25.95	8
θ *Persei*	2 37 1.631	7	+48 47 2.77	6
F.11 *Arietis*	2 43 18.141	7	26 49 38.87	7
γ *Persei*	2 57 41.379	4	53 5 41.90	4
ρ *Persei*	2 58 26.795	4	38 25 59.53	4
β *Persei*	3 1 20.127	8	40 33 3.31	8
α *Persei*	3 16 49.474	8	49 29 13.51	8
δ *Persei*	3 35 26.839	6	47 27 5.16	6
ν *Persei*	3 38 3.580	5	42 14 47.60	5
η *Tauri*	3 41 14.522	5	23 46 48.86	5
ζ *Persei*	3 47 31.827	6	31 34 17.75	6
ε *Persei*	3 50 18.393	3	39 42 22.04	3
ξ *Persei*	3 52 9.031	6	+35 29 19.90	6

OBSERVATIONS OF SMALL PLANETS.

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY A. JAY ROY.

Albany M.T.		*	No. comp.	Planet — *		Planet's Apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
				Irene (14)					
1894	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 7	11 58 42	1	4	−2 14.04	+1 14.0	0 57 7.20	−8 12 38.5	8.227	0.835
				Europa (52)					
Nov. 1	13 39 25	2	6	+2 38.02	−6 46.5	2 28 43.10	+2 52 11.6	9.327	0.754
1	9 4 53	3	4	+2 6.24	+0 14.8	26 30.65	+2 41 52.3	*n*9.409	0.757
6	7 22 40	3	9	+0 36.00	−6 18.9	25 0.42	+2 35 18.5	*n*9.573	0.764
10	13 13 25	4	5	−3 18.48	+1 0.1	24 45.53	+2 22 30.5	9.375	0.758
15	12 53 55	5	9	+0 0.01	+4 11.2	18 8.59	+2 10 41.8	9.388	0.760
				Angelina (64)					
Oct. 18	13 29 39	6	8	−0 59.78	+3 22.2	1 30 32.60	+11 39 45.4	9.311	0.669
	14 47 53	7	8	−1 36.35	+6 46.8	30 29.40	+11 39 27.5	9.512	0.694
19	7 47 34	6	9	−1 40.06	−0 29.2	29 52.33	+11 35 54.1	*n*9 570	0.710
	8 18 13	7	10	−2 14.88	+3 6.9	29 50.88	+11 35 47.7	*n*9.528	0.698
26	15 16 35	8	6	−3 11.63	−10 43.0	23 27.95	+10 58 44.2	9.600	0.725
				Freia (76)					
Dec. 3	14 32 5	9	7	+0 59.11	+8 2.1	5 27 21.05	+20 58 36.9	*n*9.104	0.522
5	9 32 25	9	6	−0 31.69	+5 30.5	25 47.27	+20 56 5.0	*n*9.505	0.589
	9 48 43	10	6	−1 46.87	−0 52.4	25 46.88	+20 56 4.8	*n*9.470	0.576
19	13 4 54	11	5	−3 15.30	+9 0.7	13 57.13	+20 37 31.8	9.317	0.547
				Sylvia (87)					
Oct. 21	12 24 51	12	6	−1 1.72	−1 49.2	2 26 10.49	+3 11 48.8	7.558	0.747
26	16 32 12	13	8	−1 4.82	−1 25.0	22 12.23	+3 4 56.1	9.607	0.765
27	7 10 32	14	8	−0 20.89	+0 2.7	21 14.57	+3 3 53.9	*n*9.616	0.767
28	7 6 3	15	8	+1 3.00	−5 57.5	20 58.35	+3 2 15.1	*n*9.615	0.767
29	7 4 4	14	6	−1 53.49	−3 12.1	20 11.99	+3 0 39.0	*n*9.614	0.767
				Gallia (148)					
Nov. 28	11 52 33	16	7	+1 45.49	−2 57.0	4 24 35.74	−20 39 16.7	–	0.896
Dec. 3	9 35 26	17	6	+1 15.09	+7 34.8	20 17.64	−20 23 17.2	*n*9.344	0.880
5	11 29 27	18	6	−1 1.41	+8 1.4	18 30.91	−20 13 20.0	8.336	0.895
14	12 8 44	19	6, 8	+1 23.49	−0 58.3	11 28.58	−19 8 57.4	9.257	0.881
				Laurentia (162)					
Oct. 1	9 36 30	20	6	−2 0.81	−1 50.4	0 24 18.23	−2 24 9.5	*n*9.352	0.792
6	12 32 56	21	7	+1 11.05	+5 23.0	20 19.30	−2 42 31.8	9.154	0.796
7	11 0 27	21	9	+0 28.18	+2 10.9	19 36.46	−2 45 43.8	*n*8.360	0.797

Albany M.T.	*	No. comp.	Planet — *		Planet's Apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
			Idunna (176)					
1894 h m s			m s	′ ″	h m s	° ′ ″		
Sept. 11 12 4 42	22	10	−0 48.14	+ 1 51.5	0 33 43.28	+14 59 44.5	*n*9.095	0.617
20 10 37 5	23	9	+1 2.52	+ 4 58.4	28 53.25	+13 20 36.6	*n*9.321	0.651
21 10 23 4	23	11	+0 27.21	− 7 0.8	28 17.96	+13 8 37.5	*n*9.353	0.656
25 8 24 15	24	12	−0 19.31	− 1 0.1	25 56.30	+12 19 20.8	*n*9.564	0.702
27 8 44 40	25	7	+4 31.90	− 4 22.5	21 41.99	+11 53 5.6	*n*9.520	0.694
Oct. 1 12 21 51	26	8	−3 57.04	+ 0 4.4	22 7.75	+10 57 20.9	8.921	0.666
			Ismene (190)					
Oct. 21 11 42 5	27	7	+4 3.24	+ 4 9.9	2 28 2.71	+ 9 10 7.1	*n*8.921	0.687
28 8 16 53	28	8	−0 20.06	+ 7 17.2	23 40.14	+ 8 39 39.9	*n*9.553	0.726
29 7 43 6	28	6	−0 57.99	+ 3 0.7	23 2.21	+ 8 35 23.4	*n*9.588	0.735
Nov. 1 12 4 25	29	8	−1 12.94	− 1 41.2	20 57.80	+ 8 21 38.0	8.748	0.695
6 11 22 3	30	5	−4 48.89	+ 1 33.3	17 46.36	+ 8 1 3.4	8.269	0.699
			Scea (329)					
Dec. 22 10 30 24	31	6	−4 10.45	+ 1 59.9	4 40 29.01	− 2 37 26.7	*n*7.818	0.796
			Planet *AD* (371)					
Nov. 28 7 14 32	32	7	−2 26.31	− 3 9.1	2 12 52.00	+22 53 45.3	*n*9.450	0.539
29 6 57 25	33	6	−0 44.35	+ 6 29.9	12 18.48	+22 47 40.6	*n*9.480	0.551
Dec. 3 7 53 58	34	10	−1 35.20	+12 44.2	10 15.21	+22 23 26.9	*n*9.231	0.505
			Planet *BE*.					
Dec. 15 7 3 28	35	10	−0 17.69	− 2 6.6	2 29 56.95	− 4 30 9.5	*n*9.297	0.806
18 6 56 12	36	7 , 6	+0 28.67	+ 4 0.7	31 19.45	− 4 39 54.1	*n*9.284	0.808
19 6 6 6	36	10	+0 58.45	+ 1 41.5	31 49.22	− 4 42 13.4	*n*9.428	0.804
			Hermione (121)					
1895 Jan. 12 7 53 12	37	6 , 8	+0 23.44	−1 43.2	6 24 49.65	+27 29 47.1	*n*9.544	0.503
14 11 18 22	37	6	−1 14.10	+1 18.0	23 12.11	+27 32 48.4	8.842	0.362
			Planet *BJ*. (369)					
Jan. 19 7 26 49	38	7	+2 7.70	+2 34.6	2 26 23.43	+ 5 35 28.5	9.031	0.726
27 7 46 57	39	8	+0 41.92	−8 22.4	32 43.32	+ 6 57 34.0	9.277	0.717

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 59 17.57	+3.64	− 8 14 47.3	+24.8	Albany, 2 observations
2	2 26 1.27	+3.81	+ 2 58 32.7	+25.4	A.G. Albany 704, Schjellerup 707
3	2 24 20.57	+3.84	+ 2 41 12.6	+24.9	A.G. Albany 695
4	2 25 0.15	+3.86	+ 2 21 5.9	+24.5	A.G. Albany 699
5	2 18 4.70	+3.88	+ 2 6 5.9	+24.7	A.G. Albany 667
6	1 31 28.74	+3.64	+11 35 57.7	+25.5	American Ephemeris (*π Piscium*)
7	1 32 2.10	+3.65	+11 32 15.2	+25.5	Paris 2017, Glasgow 360
8	1 26 35.90	+3.68	+11 9 1.4	+25.8	Albany, 2 observations
9	5 26 17.22	{ +4.72 { +4.74	+20 50 22.1	{ +12.7 { +12.4	Rümker 1461
10	5 27 29.01	+4.74	+20 56 44.6	+12.6	Albany, 1 observation
11	5 17 7.52	+4.91	+20 28 17.6	+13.5	Albany, 2 observations
12	2 27 8.20	+3.71	+ 3 16 12.7	+25.3	A.G. Albany 709, Glasgow 568, Yarnall 1161
13	2 23 13.30	+3.75	+ 3 5 56.2	+25.2	A.G. Albany 687
14	2 22 1.71	{ +3.75 { +3.77	+ 3 3 26.0	{ +25.2 { +25.1	A.G. Albany 679
15	2 19 51.59	+3.76	+ 3 7 47.4	+25.2	A.G. Albany 673, Schjellerup 687
16	4 22 46.36	+3.89	−20 36 37.7	+18.0	Albany, 2 observations
17	4 18 58.58	+3.94	−20 31 9.1	+17.1	Yarnall 1941, Bonn VI, 52

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
18	4 19 28.36	+3.96	−20 21 37.7	+16.6	Albany, 2 observations
19	4 10 1.08	+4.01	−19 8 13.8	+15.0	Albany, α 1 and δ 2 observations
20	0 26 15.51	+3.53	− 2 22 42.9	+23.8	Gould 441, Karlsruhe
21	0 19 4.70	+3.55	− 2 48 18.3	+23.5	Gould 316, Yarnall, Karlsruhe, etc.
22	0 34 28.19	+3.23	+14 57 31.7	+21.3	Albany, 2 observations
23	0 27 47.40	+3.33	+13 15 15.6	+22.6	Albany, 2 observations
24	0 26 12.21	+3.40	+12 19 57.5	+23.4	Munich I and II, W. Bessel 396
25	0 20 6.68	+3.41	+11 57 4.7	+23.4	Albany, 2 observations
26	0 26 1.38	+3.41	+10 56 52.7	+23.8	Paris 610, Glasgow 137, etc.
27	2 23 55.72	+3.75	+ 9 5 32.2	+25.0	Glasgow, Paris, Yarnall 1137
28	2 23 56.41	+3.79	+ 8 31 57.6	+25.1	Albany, 1 observation
29	2 22 6.91	+3.83	+ 8 22 54.0	+25.2	Albany, 2 observations
30	2 22 31.37	+3.88	+ 7 59 4.9	+25.2	American Ephemeris (ξ^2 *Ceti*)
31	4 41 35.17	+4.29	− 2 39 10.6	+14.0	Albany, 2 observations
32	2 15 14.25	+4.06	+22 56 27.1	+27.3	Albany, 2 observations
33	2 12 58.78	+4.05	+22 40 43.3	+27.4	Armagh, Paris 2868
34	2 11 46.37	+4.04	+22 10 15.0	+27.7	Albany, 2 observations
35	2 30 10.74	+3.90	− 4 28 23.3	+20.4	Albany, 2 observations
36	2 30 46.90	+3.88	− 4 44 14.8	+20.0	Glasgow I and II
			Mean Places for 1895.0.		
37	6 24 24.39	+1.82	+27 31 22.2	+ 8.1	W. Bessel 627
38	2 24 15.25	+0.48	+ 5 32 49.1	+ 4.8	Bonn VI, 344
39	2 32 0.97	+0.43	+ 7 5 51.2	+ 5.2	W. Bessel II, 504

Star 1, adopted p.m., +0s.003, +0″.11. Star 21, adopted p.m., −0s.003, 0″.00.

Star 24, adopted p.m., −0s.008, −0″.16. Star 26, precession of Glasgow 137 should be +3s.0997, instead of +3s.1117

NEW VARIABLE IN *CETUS*, SDM. −15°6531,

23h 54m.7 −15° 29′.5 (1855).

By AARON N. SKINNER, Assistant Astronomer.

[Communicated by Prof. Wm. Harkness, Astronomical Director, Naval Observatory.]

In the course of the observation of the Washington Zone −13° 50′ to −18° 10′, on each of the three dates, Nov. 1, 12 and 14, 1894, I failed to see with the 9-inch transit-circle the star SDM. −15°6531, which Schonfeld called 8M.4, and Argelander in Band VI of the Bonn observations called 9M.0. A scrutiny of the region with the equatorial showed in this place a star of the magnitude 12 to 13. At my request Assistant Astronomer Paul of this observatory made careful comparisons of this star with neighboring comparison-stars on eight different dates, from 1894 Nov. 24 to 1895 Jan. 22, and observed an increase in brightness of about three magnitudes. At the latter date it had reached nearly to the ninth magnitude, and had apparently not passed a maximum. The star could be followed no longer, on account of the evening twilight.

Washington, D.C., 1895 *April* 2.

NEW ASTEROIDS.

Prof. Kreutz communicates the discovery of four more asteroids, two by Prof. Wolf March 15 and 16, and two by Mr. Charlois March 15 and 21. Their positions were

BT 12½M March 16 10h 31m.6 Heidelb. M.T. α = 11h 56m 36s, δ = + 6° 51′. Daily motion, −48s in α, and 1′ northward.
BU 14M March 15 9 50.0 Nice M.T. α = 11 5 56, δ = − 0 46. Daily motion, −48s in α, and 2′ northward.
BV 13M March 15 9 50.0 Heidelb. M.T. α = 11 12 40, δ = + 4 58. Daily motion not yet known.
BW 11M March 21 9 37.0 Nice M.T. α = 11 50 4, δ = +17 15. Daily motion, −48s in α, and 8′ northward.

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Observations of the Diameter of Neptune and of the Position of his Satellite, by Prof. E. E. Barnard.
Meridian Observations of Algol and other Stars, by Prof. Lewis Boss.
Observations of Small Planets, by Mr. A. Jay Roy.
New Variable in Cetus, SDM. −15°6531, by Mr. Aaron N. Skinner.
New Asteroids.

Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed April 6.*

THE

ASTRONOMICAL JOURNAL.

No. 343.

VOL. XV. BOSTON, 1895 APRIL 25. NO. 7

ON THE PROPER MOTION OF *ALGOL*,

By LEWIS BOSS.

It is well known that the interval between the light-minima of *Algol* undergoes a periodic variation. Dr. CHANDLER finds this period to be about 131 years, and advances a hypothesis to account for it. According to this hypothesis *Algol*, with its known eclipsing companion, revolves about a distant center of gravity determined by its relation to a third body. Recently, Mr. TISSERAND has advanced another hypothesis (*C.R.* CXX, no. 3), which also seems to account for the periodic variation in the interval of light-changes, namely, that the orbits of the components of the *Algol* pair are sensibly eccentric, and that a revolution of the line of apsides is caused by a hypothetical polar compression of *Algol*. That the two bodies of the *Algol*-system must have a period of rotation synchronous with that of orbital revolution seems to be an essential requirement for the stability of that system. Under this assumption the period of rotation would be less than 69 hours. The resulting compression would evidently be of some importance. Therefore it seems very probable that the hypothesis of Mr. TISSERAND may ultimately be shown to explain some part of the periodicity.

In the endeavor to decide upon the relative importance of these two hypotheses in relation to the observed periodicity of the light-interval, or in considering whether one of them should be held to exclude the other, wholly or in the greater part, two distinct sources of evidence must be consulted.

(1) Mr. TISSERAND's hypothesis requires a periodic variation of large amount in the duration of the minimum phase of *Algol*; the question, whether such variation in the required degree has actually been observed, must undergo satisfactory examination.

(2) On the other hand, Dr. CHANDLER's hypothesis requires a periodic inequality in the proper motion of *Algol*. It is evident that the tenability of this hypothesis does not rest upon the ability actually to recognize an inequality in the proper motion of *Algol* (*A.J.* XI, p. 113). Nevertheless, the certain recognition of such an inequality would constitute the most conclusive and unanswerable element in the proof; it would establish the validity of Dr. CHANDLER's hypothesis.

I wish now to consider briefly this second line of evidence, — that which concerns the proper motion of *Algol*. To anticipate somewhat, one may venture the opinion that, if there exists in the proper motion of *Algol* a periodic variation of the general nature of that indicated by Dr. CHANDLER's computations (*A.J.* XI, nos. 255, 6), its coefficient is likely to be under rather than over $0''.7$. In view of the material at hand, the problem is evidently one of extreme delicacy. It may be of interest, however, to inquire whether a more elaborate investigation would be advisable, and whether this star merits further special attention from meridian observers.

In a problem of such delicacy the mode of treatment should be strictly that of differential observation. In practice this ideal cannot be reached. Considering the question in a summary way, and concretely with reference to this particular case, we may proceed in any one of the following ways.

(1) One might apply to the several observed positions of *β Persei* the systematic corrections of Dr. AUWERS (*A.N.* 3195, 6), deducing others in like manner for catalogues not included in his tables. This would be practically a comparison of the place of *Algol* with those of the stars in a wide area around it; and much might be said in favor of this method.

(2) One might select a limited number of comparison-stars irrespective of any system of corrections, and then refer the catalogue-places of *β Persei* to them, virtually deriving from each catalogue values of $\Delta\alpha$ and $\Delta\delta$ from each comparison-star. This method requires for its perfection that each catalogue should contain each comparison-star with practically uniform weight of observation, a condition by no means realized in this instance.

(3) One might seek to avoid this difficulty by computing positions for each of the comparison-stars in closest possible conformity with the system of the *Fundamental-Catalog* as now defined by the tables of Dr. AUWERS. The

omission of one or more of these stars from a given catalogue would then be of less serious consequence.

I have used a combination of methods (1) and (3). The comparison-stars are the 13 selected by Dr. CHANDLER (see *A.J.* Vol. XI, nos. 255, 6 and *V.J.S.* XXIX, p. 215). For the positions of these, referred to the system of Dr. AUWERS, I adopt the results found by Dr. BAUSCHINGER (*V.J.S.* XXIX, p. 215) with two exceptions presently to be noted. In his discussion I think Dr. BAUSCHINGER overrates the relative weight which should attach to the older catalogues, especially in the case of BRADLEY. This does not happen to be productive of evil consequences in any marked degree, except in the right-ascensions of β *Trianguli* and γ *Persei*, for which I prefer the values here set forth, together with the consequent corrections of Dr. BAUSCHINGER's values at the epochs noted.

	α 1875.0	μ	Correction 1755	Correction 1900
β *Trianguli*	$2^{h}\ 2^{m}\ 6^{s}.634$	$+0^{s}.0099$	$+0^{s}.198$	$-0^{s}.077$
γ *Persei*	2 55 45.240	−0.0007	−0.078	+0.038

These represent much better the observations since BRADLEY's time.

The systematic corrections for β *Persei* will now be derived from these comparison-stars, where the given catalogue contains more than eight of them. This amounts to differentiating the place of *Algol* from these comparison-stars. At the same time the systematic corrections, thus derived, are in substantial conformity with those which might have been taken from the tables of Dr. AUWERS already cited. Therefore, when the number of the comparison-stars contained in a given catalogue was less than eight, and especially when the distribution of them about β *Persei* was unsymmetrical, I have thought it to be much safer to give some weight to the corrections derived from the general tables of Dr. AUWERS; but, at the same time, I have considered the deduced result entitled to a diminished weight, on account of the departure from strictly differential treatment. Requirements of space permit me simply to say, that uniform empirical rules for effecting this combination of systematic corrections, and for assigning the diminished ratio of weights were fully settled upon in advance of computation. In a problem of this kind uniformity of practice is of the most vital consequence.

In order to save labor in carrying out this plan, I have made use of Dr. BAUSCHINGER's tables (*V.J.S.* XXIX, pp. 216–220) for the separate catalogues. It might have been desirable to revise these in several instances; but for the sake of economy in labor I have undertaken such revision only in case of the Pulkowa right-ascensions for 1865. This is specially desirable, owing to the great weight of that catalogue; because the observations were made partly by the "eye-and-ear" method "O," and partly by the chronograph method, "R"; and because the star was also observed in both ways below the pole, "(L.C.) O," and "(L.C.) R," though at a zenith distance of 80°. Accordingly I have constructed four tables for Pulkowa 1865, in substantial conformity with those of Dr. BAUSCHINGER. The lower line of means gives the date and the adopted systematic correction for each group, from which, with a slight correction to remove the effect of adopted proper motion so as to refer the places to the adopted dates, the seconds of right-ascension, as they appear in the tables for β *Persei* later on, are derived.

CORRECTIONS IN R.A. FOR PULKOWA 1865.

	O			R			(L.C.) O			(L.C.) R		
*	Obs.	Wt.	Corr. s	Obs.	Wt.	Corr. s	Obs.	Wt.	Corr. s	Obs.	Wt.	Corr. s
1	15	5.0	+0.006	11	4	−0.021	6	2.5	−0.057	13	4.5	−0.015
2	5	2.0	+0.055	17	5	−0.009						
3	2	1.0	−0.037	19	5	−0.029	3	1.5	−0.128	17	5.	−0.024
4	6	2.5	−0.017	17	5	−0.013						
5	1	0.5	−0.018	17	5	0.000	3	1.5	−0.021	18	5.	−0.026
6	3	1.5	−0.003	19	5	+0.006	3	1.5	−0.100	16	5.	−0.038
7	31	5.0	−0.012	38	5	−0.007	4	2.0	−0.015	15	5.	−0.021
8	6	2.5	−0.013	15	5	−0.029	3	1.5	−0.004	20	5.	−0.018
9	3	1.5	−0.020	12	5	+0.003	2	1.0	−0.067	2	1.	−0.083
10	18	5.0	−0.023	30	5	−0.008						
11	6	2.5	−0.007	18	5	+0.002						
12	3	1.5	−0.040	19	5	−0.013						
13	4	2.0	−0.060	18	5	−0.011						
Mean	(1861)		−0.011	(1866)		−0.010	(1862)		−0.055	(1871)		−0.026

I have also deduced systematic corrections for Greenwich 1891, for which Dr. BAUSCHINGER gives no table. In R.A. this is important, since from 7 observations of 4 comparison-stars the correction is $+0^{s}.057$, and from 38 observations of 13 stars ($\alpha = 3^{h}\ 8^{m}$, $\delta = +37°$) it is found to be $+0^{s}.054$ (adopted). Dr. AUWERS finds about $+0^{s}.04$ at this position for the later Greenwich Catalogues. I have also transferred the results for Cambridge (CHALLIS), Edinburgh, and Washington, 1885, from Dr. CHANDLER's tables (*A.J.* XI, pp. 114, 5), though these are relatively unimportant in their influence upon the result. Furthermore, I have added the special determinations made at Cambridge, Mass., by Mr. SEARLE in 1893 (*H.C.O. Annals* XXIX) and at Albany in 1895 (*A.J.* no. 342), referring each to the adopted places of the comparison-stars.

Referring to Mr. SEARLE's table V (*Ann. H.C.O.*, XXIX, p. 196), it will be seen that his directly deduced corrections to the right-ascension of β *Persei* in the *Berliner Jahrbuch* for 1893.0 are: $0^{s}.00$, $+0^{s}.01$, $+0^{s}.07$, $+0^{s}.04$, $+0^{s}.13$, $+0^{s}.08$, $+0^{s}.11$, $+0^{s}.12$, $+0^{s}.09$ and $+0^{s}.01$. Rejecting the R.A. of *Algol* in determining $H + m$ for computing its own place, the mean of these becomes $+0^{s}.074$. After supplementary treatment Mr. SEARLE arrives at $+0^{s}.105$ for this quantity; but his correction for magnitude-error which is responsible for the greater part of this increase, appears questionable, in view of the indirect and altogether insufficient evidence upon which it is founded. The glass reticule in use at Cambridge may well be a source of errors and anomalies in transit-observations, but the effect of this in work which is almost rigorously differential, as in the present instance, ought to be practically limited to a possible increase in the probable error of observation. In what follows, I shall consider the Cambridge observations to be fairly entitled to receive the relative weight finally assigned to them in the discussion.

The tables for *β Persei*, which follow, exhibit for 1875.0 the corrected seconds of R.A. and Decl. derived in the manner already indicated. These differ in many instances from those deduced by Dr. BAUSCHINGER from practically the same basis. One reason for this is found in the fact that Dr. BAUSCHINGER sometimes neglected important corrections which would naturally follow from his tables. For example, well-determined corrections of $-0^s.008$ for Pulkowa, 1865, $-0^s.010$ for Rogers, 1875, $+0^s.015$ for Washburn, 1889, $+0^s.054$ for Greenwich, 1891, and others of like nature, are ignored, while others of a similar character and under precisely similar circumstances are adopted. The adopted corrections of $-0^s.044$ for Königsberg, 1820, and of $+0^s.038$ for Camb.-Airy, 1834, each depending upon only four comparison-stars, seem to be of doubtful propriety in view of other rejections. The general effect of the omissions has been to obscure the evidence of orbital motion.

The weights adopted in the present discussion are often estimates only. This part of the work also deserves much more thorough treatment than I was able to give it in this preliminary survey. In some instances, however, and especially in declination, the weights are more carefully deduced, the prescribed mean error of the unit of weight having been taken as $\pm 0^s.055$ in R.A. and $\pm 0''.60$ in Decl. In assigning the weights, regard was had to the uncertainty of the systematic corrections, as I have already stated.

From the meridian observations of any star it would, of course, be possible to deduce periodic terms in the proper motion; but, in case these terms have no foundation in fact, we should expect the coefficients to be of the same general order of magnitude as their probable errors. Especially should we expect this to be true, if the duration of the period be assigned from considerations unconnected with the observations from which the periodic terms are to be derived. This prescription is imposed in the present problem. The definite question is, whether Dr. CHANDLER's period of 130.91 years, clearly indicated in the observations of *Algol* as a variable star, does or does not find consistent support from the meridian observations. It will be practically necessary to assume that the center of gravity of the hypothetical orbit of *Algol* lies at the center of the projected apparent ellipse. This is equivalent to the supposition that motion in the real orbit is circular and uniform. Thus the uniform yearly motion, μ'', in mean anomaly, M, will be $2^\circ.75$; and this is the foundation and only limitation of our working hypothesis. Such supposed orbital motion will give rise to terms, in each coordinate, of the form

$$x \sin \mu'' (T - T') + y \cos \mu'' (T - T')$$

in which T' is any fixed epoch and x and y are constants to be determined from observation. For convenience, let us take $T' = 1865.0$.

Column I, in each of the subjoined tables, exhibits the deviations (observed — computed), on the respective dates, under the assumption that the proper motion is rectilinear. Column II shows the corresponding differences under the otherwise unrestricted assumption that a part of the proper motion in each coordinate depends upon sine and cosine terms having a period of 130.91 years.

β Persei — RIGHT-ASCENSION, 1875.0.

	Epoch	No. Obs.	Wt.	R.A. Seconds	O—C I	O—C II
				s	s	s
Bradley	1754	9	0.5	2.660	+0.004	+0.013
Piazzi	1804	28	0.5	2.428	−0.161	−0.200
Groombridge	1810	3	0.3	2.876	+0.295	+0.259
Bessel	1820	38	3.2	2.606	+0.039	+0.013
Struve	1824	7	2.5	2.618	+0.056	+0.035
Pond	1831	8	1.0	2.523	−0.029	−0.041
Airy	1834	4	0.6	2.562	+0.014	+0.006
Taylor	1835	9	1.0	2.503	−0.044	−0.051
Armagh I	1837	5	0.5	2.411	−0.133	−0.137
Radcliffe I	1845	5	1.5	2.500	−0.033	−0.029
Paris I	1846	138	4.0	2.538	+0.006	+0.011
Greenwich	1846	3	0.8	2.508	−0.024	−0.019
Pulkowa	1847	41	6.0	2.521	−0.010	−0.003
Yarnall	1850	9	1.0	2.575	+0.048	+0.057
Greenwich	1851	7	1.2	2.501	−0.024	−0.015
Radcliffe II	1857	5	0.6	2.473	−0.044	−0.033
Greenwich	1860	3	0.9	2.436	−0.077	−0.065
Paris II	1861	170	4.0	2.517	+0.005	+0.017
Pulkowa O	1861	5	2.0	2.482	−0.030	−0.018
Pulk. (L.C.) O	1862	3	1.0	2.519	+0.009	+0.020
Greenwich	1864	12	3.5	2.503	−0.005	+0.007
Brussels	1865	3	0.8	2.487	−0.019	−0.008
Camb.-Saff.	1865	19	3.2	2.517	+0.011	+0.022
Bonn	1866	8	0.8	2.518	+0.013	+0.024
Pulkowa R	1866	16	6.0	2.511	+0.006	+0.017
Leipsic	1867	9	1.0	2.437	−0.067	−0.057
Pulk. (L.C.) R	1871	14	1.5	2.544	+0.046	+0.054
Greenwich	1873	5	2.0	2.493	−0.003	+0.004
Paris III	1875	36	3.0	2.467	−0.026	−0.022
Camb.-Rogers	1875	53	6.0	2.491	−0.002	+0.002
Berlin-Romb.	1875	14	4.0	2.452	−0.041	−0.037
Pulk.-Romb.	1876	22	5.0	2.493	+0.002	+0.005
Greenwich	1881	6	2.0	2.479	−0.006	−0.009
Paris IV	1883	19	1.5	2.455	−0.027	−0.032
Washington	1885	7	1.0	2.490	+0.011	+0.002
Washburn	1889	10	4.0	2.480	+0.006	−0.008
Greenwich	1891	4	1.3	2.543	+0.072	+0.054
Camb.-Searle	1893	10	3.0	2.524	+0.056	+0.035
Albany	1895	8	4.0	2.470	+0.004	−0.020

β Persei — DECLINATION, 1875.0.

	Epoch	No. Obs.	Wt.	Decl. Seconds	O—C I	O—C II
				"	"	"
Bradley	1754	4	0.5	19.12	−1.64	−0.39
Mayer	1755	4	0.2	20.91	+0.15	+1.39
Piazzi	1803	6	0.4	20.53	−0.12	−0.16
Groombridge	1810	12	1.0	20.95	+0.31	+0.19

	Epoch	No. Obs.	Wt.	Decl. Seconds	O—C I	O—C II
				″	″	″
Bessel	1821	23	2.0	20.55	−0.06	−0.30
Struve	1824	7	2.5	20.58	−0.02	−0.27
Pond	1831	12	1.5	21.71	+1.15	+0.93
Airy	1834	2	0.5	20.03	−0.55	−0.75
Taylor	1835	17	0.5	20.04	−0.54	−0.73
Challis	1837	11	1.0	20.44	−0.14	−0.31
Armagh I	1838	8	0.5	20.31	−0.26	−0.42
Challis	1838	6	0.8	21.28	+0.71	+0.55
Challis	1840	10	1.0	20.98	+0.41	+0.27
Greenwich	1840	10	2.0	20.67	+0.10	−0.04
Bessel	1840	20	1.5	21.33	+0.76	+0.62
Henderson	1842	7	1.5	21.02	+0.45	+0.34
Pulkowa	1845	2	1.5	20.61	+0.05	−0.03
Greenwich	1846	3	1.0	21.58	+1.02	+0.96
Radcliffe I	1846	4	0.6	20.33	−0.23	−0.29
Paris I	1847	128	3.6	20.08	−0.48	−0.53
Greenwich	1851	4	1.0	20.51	−0.04	−0.04
Challis	1851	2	0.5	21.78	+1.23	+1.23
Radcliffe II	1859	4	0.5	19.43	−1.10	−1.02
Greenwich	1860	3	1.2	20.36	−0.17	−0.08
Paris II	1862	84	5.0	20.59	+0.07	+0.17
Brussels	1862	2	0.5	20.49	−0.03	+0.07
Yarnall	1863	4	0.8	19.71	−0.81	−0.71
Greenwich	1865	11	3.0	20.07	−0.45	−0.33
Bonn	1866	8	1.0	21.29	+0.78	+0.89
Leipsic	1867	9	1.0	20.07	−0.44	−0.32
Leiden	1870	16	2.0	20.48	−0.02	+0.10
Pulkowa	1873	4	3.0	20.29	−0.21	−0.09
Greenwich	1873	10	3.0	20.43	−0.07	+0.05
Paris III	1875	39	4.0	20.09	−0.40	−0.29
Camb.-Rogers	1875	49	5.0	20.18	−0.31	−0.20
Pulk.-Romb.	1876	19	4.0	20.57	+0.08	+0.19
Greenwich	1879	13	4.0	20.79	+0.30	+0.39
Paris IV	1883	21	2.0	20.55	+0.07	+0.11
Pulkowa	1885	9	6.0	20.52	+0.05	+0.06
Washington	1885	6	1.0	20.37	−0.10	−0.09
Washburn	1889	12	5.0	20.33	−0.13	−0.19
Greenwich	1891	4	1.5	20.56	+0.10	+0.01
Camb.-Searle	1893	10	3.0	20.76	+0.30	+0.17
Albany	1895	8	5.0	20.62	+0.17	−0.02

The solution of the conditional equations constructed in accordance with the two hypotheses has been rigorous. Supposing rectilinear motion to represent the observations, we have for 1875.0:

$$\alpha = 3^h\ 0^m\ 2^s.493 \quad -0^s.00135\,(T-1875)$$
$$\delta = 40^\circ\ 28'\ 20''.49 \quad -0''.0022\ \ (T-1875).$$

The probable errors of the units of weight are $\pm 0^s.037$ and $\pm 0''.37$ respectively.

Under the second supposition, involving periodic terms in the expression for proper motion, we have for 1875.0:

$$\begin{array}{llll} \alpha = \ \ 3^h\ 0^m\ 2^s.513 & -0^s.00122\,(T-1875) & +0^s.0046 \sin 2^\circ.75\,(T-1865) & -0^s.0301 \cos 2^\circ.75\,(T-1865) \\ \qquad\quad \pm 0^s.008 & \pm 0^s.00036 & \pm 0^s.0109 & \pm 0^s.0098 \end{array}$$

$$\begin{array}{llll} \delta = 40^\circ\ 28'\ 20''.83 & +0''.0072\,(T-1875) & -0''.287 \sin 2^\circ.75\,(T-1865) & -0''.346 \cos 2^\circ.75\,(T-1865) \\ \qquad\quad \pm 0''.07 & \pm 0''.0030 & \pm 0''.093 & \pm 0''.097 \end{array}$$

The respective probable errors of the units of weight are $\pm 0^s.036$ and $\pm 0''.35$, the sums of the squares of residuals having been reduced from $0^s.1131$ to $0^s.0955$ in R.A. and from $13''.021$ to $10''.674$ in declination. Taking the epoch for the mean anomaly, M, at 1865

$$[M = 2^\circ.75\,(T-1865)],$$

the periodic terms may be reduced to the more convenient form

$$\begin{array}{cc} \text{for } \alpha & \text{for } \delta \\ 0''.348 \sin (M + 278^\circ.7)\,; & 0''.419 \sin (M + 230^\circ.3) \\ \pm 0''.113 \qquad\qquad \pm 20^\circ.6 & \pm 0''.096 \qquad\qquad \pm 12^\circ.1 \end{array}$$

In right-ascension the coefficient of the inequality is three times its probable error; and in declination, it is more than four times the probable error. Leaving entirely out of the account considerations based upon the behavior of *Algol* as a variable star, the degree of mathematical probability in favor of the assumption, that the foregoing results represent an actual inequality in the proper motion, must be set over against the *a priori* presumption against the reality of variable proper motion for any given star. The discussion of this point in the present state of our knowledge could lead to no precise result. Taking the result of this computation apart from any other consideration I venture the opinion, however, that there is a preponderance of probability in favor of the real existence of a periodic element in the proper motion of *Algol*. Were this star of the fourth magnitude instead of the second, I should not hesitate to say that this preponderance is large.

Let us now consider the foregoing numerical results in connection with the observations of *Algol* as a variable star. Supposing the periodic terms to be real, they indicate that the apparent motion of the star is an ellipse. The position-angle of the northern end of the major axis is 34°; the semi-axis major is $0''.522 \pm 0''.103$, and the semi-minor, $0''.224$: the inclination of the real orbit to our line of sight under the hypothesis of circular motion is 23°. Under the fundamental hypothesis, *Algol* would have passed through the plane perpendicular to the line of sight at the center of gravity of the hypothetical system in $1808 \pm 4^y.5$. Dr. Chandler finds for this date 1804 (*A.J.* XI, p.124). Consulting Dr. Chandler's table (*A.J.* XI, p.121, col. "O"), in order to have the testimony of the variable-star observations alone, it will be seen that, under the hypothesis, this date must be somewhere between limits of about 1802 to 1812, and apparently very near 1807. The coincidence of these dates computed from two entirely distinct sources of evidence (except for the assumption of the period 130.91 years in common) appears to me as significant as it certainly was unforeseen. We may summarize the state of the case thus. The foregoing computation indicates that *Algol* revolves in an orbit of which the maximum calculated radius is five times its probable error; and the same computation indicates that the star passed the major axis of the apparent orbit within 3 or 4 years from the most probable date derived from the observations of *Algol* as a variable star.

The probability in favor of Dr. CHANDLER's hypothesis seems to me at least great enough to justify a much more thorough discussion of the meridian observations than has yet been produced. It seems to me also very desirable that several observers should give special attention to this star upon the plan of differential observation from the 13 selected comparison-stars. Fifty observations by five different observers, would probably be more valuable than twice as many by a single observer, other things being equal. If the hypothesis be true, the apparent orbital motion of *Algol* is now little less than its maximum, and will so continue to be for nearly 25 years. It would be possible to settle the matter beyond a doubt within that time.

THE PARALLAX OF η *CASSIOPEAE*, DEDUCED FROM RUTHERFURD PHOTOGRAPHIC MEASURES,

BY HERMAN S. DAVIS.

[Communicated by J. K. REES, Director.]

In 1870, '71, '72 and '73, twenty-seven negatives of the stars about η *Cassiopeae* were taken by RUTHERFURD. The measures of these plates were recently placed in the writer's hands by Professor J. K. REES, to be reduced for parallax. The conditions of exposure, and indeed even the dates, as well as also the methods of measurement and of reduction are almost identical with those of μ and θ *Cassiopeae* already reduced* for parallax by Professor HAROLD JACOBY; hence reference to his paper will make clear the plan followed.

In view of the great difficulty of getting comparison-stars suitably situated, either with respect to position-angle or distance, I decided to take a larger number than is usual, and have consequently reduced six pairs—being all that were impressed on the plates sufficiently often in both seasons of the year. Every observation and every plate was used. The comparison-stars used are:

Comp. Star	Helsingfors and Gotha A.G.C.	Magnitude	Approximate Position referred to η *Cassiopeae* Distance	Position-Angle
			″	° ′
a	658	8.9	1316	3 23
b	639	8.8	1148	203 36
c	687	8.2	3416	15 24
d	621	8.8	2100	210 47
e	713	9.0	1820	113 34
f	609	8.4	1708	295 43
g	730	7.5	3052	136 10
h	607	9.0	2828	325 19
i	665	7.1	2744	175 18
j	649	8.8	2604	357 59
k	659	8.8	2156	2 53
l	663	8.3	1848	174 28

The separate results are:

Comparison pair.	Parallax.	Probable error.	Weight.	Probable error of one equation.
	″	″		″
a and *b*	+0.349	±0.086	21.7800	±0.403
c *d*	+ .385	± .084	28.9724	± .362
e *f*	+ .568	± .056	29.6264	± .305
g *h*	+ .662	± .078	8.2443	± .271
i *j*	+ .660	± .138	6.1457	± .342
k *l*	+ .297	± .155	6.1365	± .384

Only the first three of these pairs are so situated with reference to the parallactic ellipse as to give good parallax-coefficients. From these three we get, by weight,

$$\pi = +0''.443 \quad \pm 0''.043$$

or

$$= +0''.465 \quad \pm 0''.044$$

by the combination of all six pairs. This parallax corresponds approximately to a distance of η *Cassiopeae* from the earth of 43 113 000 000 000 miles, or seven and one-third light-years. Using GRÜBER's values of the orbital elements the mass of the combined system is two-tenths as great as that of the sun and the distance between the components is nineteen astronomical units—their relative orbit being therefore about the same size as that of *Uranus*.

Considering the difficulties that beset the investigation of the parallax of this star and the probability that all previous determinations have been made with a single comparison-star (DM. 57°155) which itself may have a parallax; considering also the discrepant and confessedly unsatisfactory results* of other observers, it would seem that the result here given is not improbably large, if the RUTHERFURD plates are subject to no systematic error.

Columbia College Observatory, New York City, 1895 *March* 8.

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* *The Parallaxes of μ and θ Cassiopeae, deduced from Rutherfurd Photographic Measures*, by HAROLD JACOBY. Annals N.Y. Academy of Sciences, Vol. VIII, pages 1–23.

* *Bulletin physico-mathématique de l'Académie de Saint Petersbourg.* Vol. xiv, p. 228. *Annales de l'Observatoire de Moscou* Vol. viii. part ii, p. 89.

OBSERVATIONS OF *β PERSEI* WITH THE MERIDIAN CIRCLE OF HARVARD COLLEGE OBSERVATORY.

By ARTHUR SEARLE.

[Communicated by Professor E. C. PICKERING, Director of the Observatory.]

The first series of these observations was made during December, 1892, and January, 1893, and was published in Volume XXIX of the Annals of the Observatory. A second series of observations was made in December, 1893, and January, 1894. It has not yet been fully prepared for publication; but, so far as *β Persei* itself is concerned, there is little reason to think that any material change will be made in the provisional results already obtained. These results give, for the correction to the Berlin *Jahrbuch*, in right-ascension, $+0^{s}.027$, with the probable error $\pm 0^{s}.012$; in declination, $-0''.16$, with the probable error $\pm 0''.10$. This second series of observations does not confirm the hypothesis of a considerable personal equation dependent on stellar magnitude, which was suggested by the first series. Without any correction for an error of this kind, the mean of the two series would give corrections to the Berlin *Jahrbuch* of $+0^{s}.056$ and $-0''.20$.

RESEARCHES ON THE ORBIT OF η *CASSIOPEAE* = Σ 60,

By T. J. J. SEE.

The double star *η Cassiopeae* was discovered August 17, 1779, by Sir WILLIAM HERSCHEL, who found the distance to be 11″.09, and estimated the angle approximately at 70°. At the epoch 1780.52 HERSCHEL made the distance 11″.46, but did not measure the angle of position until 1782.45, when he found it to be 62°.07. HERSCHEL observed the angle to be 70°.8, in 1803, but made no measure of the distance. The earliest observation of both angle and distance is a rough measure by BESSEL, in 1814; and although his angle is nearly correct, it is evident from the subsequent work of STRUVE that the distance is considerably too small. Since the time of STRUVE *η Cassiopeae* has been followed by nearly all of the best observers; so that we have good material upon which to base an orbit which seems likely to be substantially correct.

Having collected all the published observations from original sources, I have formed for each year a mean position which is the arithmetic mean of the mean results obtained by the best observers. In accordance with the experience of STRUVE, OTTO STRUVE, DEMBOWSKI, and BURNHAM, these yearly means may be held to furnish the surest basis for the elements of an orbit. Although the observations of *η Cassiopeae* do not suffice to fix all the elements so well as might be desired, yet it appears that the range of uncertainty is comparatively unimportant, except in case of the periodic time, which may possibly differ several years from the value here derived. Some of the other orbits found for *η Cassiopeae* are indicated by the following Table of Elements:

P	*T*	*e*	*a*	☊	*i*	*λ*	Authority	Source
yrs.			″	°	°	°		
181	1896.0	0.77083	10.335	25.55	57.98	243.65	Powell	*M.N.*, vol. XXI, p. 66
176.37	1924.78	0.6268	10.68	50.80	68.5	245.9	Dunér	*Mes. Micro.*, p. 166
222.435	1909.24	0.5763	9.83	39.95	53.83	223.33	Doberck	*A.N.* 2091
195.235	1901.25	0.6244	8.639	33.33	18.3	229.45	Grüber	*A.N.* 2111
167.4	1904.0	0.622	8.702	41.02	52.09	233.1	Coit	*M.N.*, vol. XLII, p. 359
208.1	1908.9	0.500	8.45	47.1	47.6	214.2	Lewis	*M.N.*, vol. LV, p. 20

By the method of KLINKERFUES we find the following elements of *η Cassiopeae*:

P = 190.50 years.
T = 1906.12
e = 0.547
a = 8″.2047
☊ = 13°.0
i = 46°.08
λ = 222°.02
n = +1°.88976

Apparent orbit:

Length of major axis = 15″.46
Length of minor axis = 10″.04
Angle of major axis = 51°.8
Angle of Periastron = 255°.0
Distance of star from center = 3″.94

The comparison of these elements with the observations discloses the existence of sensible systematic errors in some of the measures; and although both angles and distances are occasionally thus affected, the errors in most cases are relatively small. The constancy of the areal velocity of the radius vector indicates that the recent measures of distance are somewhat too large, but such an over estimation of the distance can hardly be considered remarkable in case of unequal stars, where the error of observation would be likely to increase as the stars approach. The following table shows the computed and observed places:

t	θ_0	θ_c	ρ_0	ρ_c	$\theta_0-\theta_c$	$\rho_0-\rho_c$	n	Observers
	°	°	″	″	°	″		
1779.81	70 ±	57.5	11.09	11.33	+12.3	−0.24	1	Herschel
1780.52	–	57.7	11.46	11.35	–	+0.11	1	Herschel
1782.45	62.1	59.0	–	11.42	+ 3.1	–	1	Herschel
1814.10	78.5	77.0	9.70	10.96	+ 1.5	−1.26	1	Bessel
1820.16	81.1	82.3	10.68	10.47	− 1.2	+0.21	5	Struve
1827.21	85.6	85.6	10.20	10.14	0.0	+0.06	1	Struve
1830.75	86.2	88.2	10.07	9.86	− 2.0	+0.21	5	Bessel
1831.75	88.7	89.0	9.69	9.78	− 0.3	−0.09	1	Herschel
1832.46	88.1	89.4	9.76	9.74	− 1.3	+0.02	7	Σ., 5; Da., 2
1835.26	91.2	91.7	9.52	9.50	− 0.5	+0.02	3	Struve
1836.74	92.1	92.9	9.39	9.38	− 0.8	+0.01	4	Struve
1841.57	97.4	96.0	9.35	9.06	+ 1.4	+0.29	8	*O*Σ., 3; Mädler, 4; Da., 1
1842.41	98.3	97.7	8.76	8.87	+ 0.6	−0.11	2–1	Mädler
1844.56	100.1	99.9	8.48	8.65	+ 0.2	−0.17	6–5	Mädler
1845.44	101.1	101.5	8.44	8.52	− 0.4	−0.08	8	Mädler
1846.66	102.5	102.1	8.57	8.44	+ 0.4	+0.13	12	Mädler
1847.37	102.2	102.8	8.38	8.39	− 0.6	−0.01	11–12	Mädler, 6–7; *O*Σ., 5
1848.12	102.5	103.5	8.60	8.33	− 1.0	−0.27	2–1	Jacob
1849.66	105.0	105.2	8.26	8.16	− 0.2	−0.10	4	Otto Struve
1850.87	106.4	106.5	8.06	8.07	− 0.1	−0.01	26	Mädler, 15–14; Mädler, 6–7; Jac., 5
1851.80	107.8	107.6	7.88	7.94	+ 0.2	−0.06	6	Mädler, 3; *O*Σ., 3
1852.61	108.5	108.6	7.65	7.87	− 0.1	−0.22	7–8	Mädler
1853.68	109.3	109.9	7.69	7.76	− 0.6	−0.07	21–15	Mädler, 5; Jac., 7; Mädler, 3; Powell, 6
1854.76	111.5	111.2	7.79	7.66	+ 0.3	+0.13	13	*O*Σ., 4; Mädler, 2; Demb., 7
1855.81	111.8	112.5	7.70	7.54	− 0.7	+0.16	22–16	Mädl., 1–3; Sec., 2; Pow., 9–4; Demb., 4; Mo., 3
1856.48	113.4	113.4	7.37	7.47	0.0	−0.10	10–9	Jac., 4; Mädler, 2–1; Demb., 4
1857.34	114.1	114.6	7.32	7.38	− 0.5	−0.06	14	Jac., 3; *O*Σ., 2; Mädler, 5; Demb., 4
1858.29	115.6	115.8	7.26	7.29	− 0.2	−0.03	10	Jac., 3; Mädler, 4; Demb., 3
1859.64	116.4	116.3	7.02	7.25	+ 0.1	−0.23	10–7	Mädler, 2–1; Pow., 6–4; Mo., 2
1860.82	119.0	119.4	7.08	7.06	− 0.4	−0.02	9–8	*O*Σ., 2; Pow., 7–6
1861.82	119.2	120.9	6.89	6.97	− 1.7	−0.08	8–7	Mädler, 5; Pow., 3–2
1862.78	120.9	122.4	6.92	6.86	− 1.5	+0.06	20	Mädler, 8; Demb., 12
1863.80	123.4	124.2	6.87	6.74	− 0.8	+0.13	9	Dembowski
1864.40	124.0	125.0	6.70	6.68	− 1.0	+0.02	13–12	Pow., 4–3; Demb., 9
1865.63	125.9	127.1	6.65	6.57	− 1.2	+0.08	17	En., 6; Demb., 8; Kn., 3
1866.60	129.6	128.8	6.60	6.49	+ 0.8	+0.11	13	*O*Σ., 2; Demb., 7; Sec., 4
1867.44	130.2	130.3	6.51	6.42	− 0.1	+0.09	8	Searle, 1; Demb., 7
1868.52	132.3	132.3	6.37	6.31	0.0	+0.06	12	Dun., 5; *O*Σ., 3; Demb., 4
1869.84	134.6	134.8	6.18	6.18	− 0.2	0.00	10	Demb. 6; Dun., 4
1870.41	135.2	135.9	6.23	6.13	− 0.7	+0.10	17–16	Pow., 5–4; *O*Σ., 2; Demb., 7; Glas., 3
1871.48	137.7	138.0	6.00	6.04	− 0.3	−0.04	10–9	Pow., 2–1; Demb., 6; Glas., 2
1872.49	139.5	140.0	6.01	5.96	− 0.5	+0.05	19	*O*Σ., 2; Dun., 7; Demb., 6; Kn., 4
1873.62	143.2	142.4	6.00	5.87	+ 0.8	+0.13	19–13	*O*Σ., 3; Demb., 7; Glas., 2; W.& S., 1; Mo., 1
1874.58	144.6	144.5	5.82	5.79	+ 0.1	+0.03	9	Dun., 1; Demb., 7; W.& S., 1
1875.54	147.4	146.7	5.67	5.71	+ 0.7	−0.04	21–19	*O*Σ., 2; Dun., 10; Demb., 7; Dk., 2
1876.70	149.2	149.4	5.52	5.62	− 0.2	−0.10	13	Demb., 7; Pl., 6
1877.73	151.0	151.8	5.62	5.54	− 0.8	−0.08	11	Demb., 6; Dk., 5
1878.77	154.2	154.4	5.42	5.48	− 0.2	−0.06	11	Demb., 5; Go., 1; Dk., 5
1879.59	159.0	156.1	5.39	5.43	+ 2.9	−0.04	15	Hall, 7; Dk., 3; Fr., 5
1880.37	160.5	158.4	5.29	5.38	+ 2.1	−0.09	12	Jed., 7; Dk., 5
1881.46	162.8	161.3	5.22	5.30	+ 1.5	−0.08	11–9	Dk., 2–1; Jed., 3–2; Pr., 2; Hall, 4
1882.59	165.8	164.2	5.11	5.23	+ 1.6	−0.12	15–14	Jed., 3; Dk., 6–5; En., 6
1883.94	168.8	168.0	5.12	5.15	+ 0.8	−0.03	3	Hall
1885.52	173.1	172.5	5.16	5.06	+ 0.6	+0.10	6	Sea., 1; Hall, 5

t	θ	θ_c	ρ_o	ρ_c	$\theta_o - \theta_c$	$\rho_o - \rho_c$	n	Observers
		°	"	"	°	"		
1886.55	176.7	175.5	4.85	5.01	+ 1.2	−0.16	20–19	En., 5; Sea, 3–2; Hall, 5; Tar. 7
1887.35	180.6	177.7	4.6	4.97	+ 2.9	−0.37	1	Smith
1888.66	182.8	182.9	4.80	4.89	— 0.1	−0.09	14	Sea., 2; Maw., 5; Hall, 4
1889.48	185.6	184.3	4.81	4.86	+ 1.3	−0.05	7	Sea., 3; Hall, 4
1890.79	188.4	188.4	5.07	4.81	0.0	+0.26	5	Hall
1891.61	191.7	191.1	4.90	4.75	+ 0.6	+0.15	9–7	See., 5–4; Maw., 4–3
1892.86	196.3	195.2	4.86	4.69	+ 1.1	+0.17	6	Com., 3; Col., 2; Jo., 1
1893.90	197.1	198.8	5.00	4.64	— 1.7	+0.36	2	Com., 1; Lov., 1
1894.07	200.9	199.3	4.92	4.62	+ 1.6	+0.30	2	Com., 1: Maw., 1
1895.16	204.3	203.2	4.99	4.54	+ 1.1	+0.45	6	Ho., 3; Com., 3.

In the last column of the table we give the abbreviated names of the observers and the number of nights on which the star was measured. Thus the record (for 1856.48) Jac., 4; Madl., 2—1; Demb., 4. means: Jacob on 4 nights; Mädler on 2 nights for angle, 1 night for the distance; Dembowski on 4 nights. The names are: Σ = W. Struve; OΣ = Otto Struve; Da. = Dawes; Madl. = Madler; Jac. = Jacob; Demb. = Dembowski; See. = Secchi; Mo. = Morton; Pow. = Powell; En. = Englemann; Kn. = Knott; Dun. = Dunér; W. & S. = Wilson & Seabroke; Dk. = Doberck; Pl. = Plummer; Go. = Goldney; Jed. = Jedrzejewicz; Fr. = Franz; Pr. = Pritchett; Sea. = Seabroke; Sr. = Searle; Gl. = Gledhill; Tar. = Tarrant; Com. = Comstock; Ho. = Hough; Col. = Collins; Lov. = Lovett; Jo. = Jones. One or two very short names are written in full.

The following ephemeris gives the position of the companion for the next ten years:

t	θ_c	ρ_c
	°	"
1895.5	204.0	4.52
1896.5	207.7	4.45
1897.5	211.5	4.36
1898.5	215.4	4.27
1899.5	219.6	4.17
1900.5	224.0	4.06
1901.5	229.4	3.92
1902.5	233.7	3.79
1903.5	239.1	3.64
1904.5	245.0	3.49
1905.5	251.4	3.33

If we adopt OTTO STRUVE's parallax of 0″.154, deduced from micrometrical measures in 1856, we find that *η Cassiopeae* is separated from us by a distance equal to 1339100 times the mean distance of the earth from the sun, and that the semi-major axis of the orbit of *η Cassiopeae* is equal to 53.277 astronomical units. When the combined mass of the sun and earth is taken as the unit, this value of the semi-major axis and the periodic time of 190.50 years lead to a mass of 4.167 for the system. This mass is considerably smaller than the values hitherto obtained, but there is no reason to think that it is too small; on the contrary, it may be, and probably is too large, especially if the parallax should prove to be larger than the value here adopted. The parallax ought to be redetermined with great care, as a good parallax would now enable us to find the mass of *η Cassiopeae* with a high degree of accuracy.

In this connection we may point out the great importance of the determination of the parallaxes of *double* rather than of *single* stars. The parallaxes of single stars are of comparatively little interest, since they give us only the distance and hence the velocity perpendicular to the line of vision, and the radiation compared to that of the sun. On the other hand, the parallaxes of double stars whose orbits are known give us, besides these data, the absolute dimensions of the orbits and the combined masses of the components—two elements of the highest importance in the study of the systems of the universe. *η Cassiopeae* is remarkable for the great angular distance of the components, and for the rapid proper motion of the system. Both of these circumstances support the belief that the star is comparatively near to us in space, and render it certain that the parallax is sensible.

In 1881 Mr. LUDWIG STRUVE discussed the relative motion of the components about the common center of gravity of the system; and from his investigation it follows that $\frac{M'}{M} = 0.268$, or the masses of the two stars are respectively 3.051 and 1.116 times the combined mass of the sun and earth. The companion is therefore more massive than the sun and moves in an ellipse nearly twice the size of the orbit of *Neptune*: but the eccentricity is so large that in periastron the companion would come considerably within the orbit of the outer planet, while at apastron it would recede to more than three times that distance.

The University of Chicago, 1895 *March* 21.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed April 22.*

THE

ASTRONOMICAL JOURNAL.

No. 344.

VOL. XV. BOSTON, 1895 MAY 8. NO. 8

ON THE FORMULAS OF PRECESSION FOR THE EQUATORIAL AND ECLIPTICAL COORDINATES,

BY KURT LAVES.

Prof. W. FOERSTER, in his lectures on Astrometry at the University of Berlin, gives a development of the formulas of precession for equatorial coordinates, which from its great generality ought to replace BESSEL's representation in the *Tabulae Regiomontanae*, adopted in the standard works of BRÜNNOW and CHAUVENET. The superiority of FOERSTER's method consists in reducing the problem to one of transformation of polar coordinates upon the surface of a sphere. By this the study of the phenomenon from the great circles themselves is done away with. The beginner especially will get a clearer insight into the effect of precession by this method, because luni-solar precession and planetary precession are throughout clearly separated from each other. I have extended FOERSTER's theory to the ecliptical system, and give below first the general theory of the transformation of polar coordinates upon the surface of a sphere, and then its application to the determination of the change which the equatorial and ecliptical coordinates undergo from the effect of precession.

I. *Transformation of polar coordinates upon the surface of a sphere.*

The position of a point S upon the surface of a sphere is given by its two polar coordinates, which are referred to a pole I and a zero circle IW. W is called the subsidiary pole. These two coordinates are: (1) The arc $IS = s$ of the great circle that passes through I and S; (2) the angle $WIS = g$ which is counted from 0° to 360° in the direction in which longitudes and right-ascensions are counted. If the pole I assumes a new position, say V, but W rests unchanged, we shall call the new coordinates of S, σ and γ, $\sigma = VS$, $\gamma = WVS$. In order to transform s into σ, and g into γ, we pass a great circle through the poles I and V. We introduce as auxiliary quantities of transformation:

$$IV = \chi, \quad WVN = \rho, \quad WIN = r$$

N designates here a point in the prolongation of VI beyond I.

In the triangle SVI the sides are

$$IV = \chi \ , \ VS = \sigma \ , \ IS = s;$$

the angles are

$$IVS = \gamma - \rho \ , \ VIS = 180 - (g - r) \ , \ VSI = S.$$

Applying the three fundamental equations of spherical trigonometry to triangle IVS we obtain

$$\left.\begin{aligned} \cos\sigma &= \cos s \cos\chi - \sin s \sin\chi \cos(g-r) \\ \sin\sigma \sin(\gamma-\rho) &= \sin s \sin(g-r) \\ \sin\sigma \cos(\gamma-\rho) &= \cos s \sin\chi + \sin s \cos\chi \cos(g-r) \end{aligned}\right\} \quad \text{(I)}$$

Since generally χ will prove to be a small arc we shall write $\cos\chi = 1 - 2\sin^2\tfrac{1}{2}\chi$ then we get

$$\cos\sigma = \cos s - \sin s \sin\chi \cos(g-r) - 2\cos s \sin^2\tfrac{1}{2}\chi,$$

or $2\sin\dfrac{\sigma+s}{2}\sin\dfrac{\sigma-s}{2} = \sin s \sin\chi \cos(g-r) + 2\cos s \sin^2\tfrac{1}{2}\chi$

therefore $\dfrac{\sigma-s}{2}$ will be a quantity of the same order as χ; neglecting higher powers than the second in χ we may put

$$\sin\chi = \chi \sin 1''.$$

and also $$\sin\frac{\sigma-s}{2} = \frac{\sigma-s}{2}\sin 1''$$

and then we may also write $\dfrac{\sigma+s}{2} = s + \dfrac{\sigma-s}{2}$

therefore $\sin\left(\dfrac{\sigma+s}{2}\right) = \sin s \cos\left(\dfrac{\sigma-s}{2}\right) + \cos s \sin\left(\dfrac{\sigma-s}{2}\right)$

Introducing this we get

$$(\sigma-s)\sin 1''\left(\sin s + \frac{\sigma-s}{2}\sin 1'' \cos s\right)$$
$$= \chi \sin 1'' \sin s \cos(g-r) + \frac{\chi^2}{2}\sin^2 1'' \cos s$$

$$\sigma - s = \chi\cos(r-g) + \frac{\chi^2}{2}\sin 1'' \operatorname{cotg} s - \frac{(\sigma-s)^2}{2}\sin 1'' \operatorname{cotg} s$$

Writing for $(\sigma-s)^2$ upon the right side $= \chi^2\cos^2(r-g)$ we shall have

$$\sigma - s = \chi\cos(r-g) + \tfrac{1}{2}\chi^2\sin^2(r-g)\sin 1'' \operatorname{cotg} s \qquad (\text{II}_1)$$

which is exact to terms including the second power in χ. In order to obtain the expression for $\gamma - g$ we first derive the value of $\rho - r$. Calling $WI = f$, $WV = \varphi$, we have, since $WVI = \rho$; $WIV = 180-r$, from triangle IVW

$$\sin f \sin r = \sin\varphi \sin\rho$$
$$\sin f \cos r = -\cos\varphi \sin\chi + \sin\varphi \cos\chi \cos\rho$$

Dividing the second equation by the first we obtain

$$\cos r \sin\rho - \sin r \cos\rho \cos\chi = -\operatorname{cotg}\varphi \sin\chi \sin r;$$

or for the same limit of exactness as above

$$\rho - r = -\chi \operatorname{cotg}\varphi \sin r - \frac{\chi^2}{2} \sin 1'' \cos\rho \sin r \qquad (\mathrm{II}_2)$$

Writing in I_2 and I_3 $\gamma-\rho = \gamma-g+(g-\rho)$ and developing upon the left side the sin and cos functions we get

$$\sin\sigma\,[\sin(\gamma-g)\cos(g-\rho)+\cos(\gamma-g)\sin(g-\rho)] = \sin s \sin(g-r)$$
$$\sin\sigma\,[\cos(\gamma-g)\cos(g-\rho)-\sin(\gamma-g)\sin(g-\rho)] = \cos s \sin\chi + \sin s \cos\chi \cos(g-r)$$

Multiplying the first of these equations by $\cos(g-\rho)$ the second by $-\sin(g-\rho)$ and adding, we obtain

$$\sin\sigma \sin(\gamma-g) = \sin s \sin(g-r)\cos(g-\rho) - \cos s \sin\chi \sin(g-\rho) - \sin s \cos\chi \cos(g-r)\sin(g-\rho)$$
$$\sin\sigma \sin(\gamma-g) = \sin s \sin(\rho-r) - \chi \sin 1'' \cos s \sin(g-\rho) + \frac{\chi^2}{2}\sin^2 1'' \sin s \cos(g-r)\sin(g-\rho)$$

Instead of $g-\rho$ we write $g-r-(\rho-r)$ and develop the sin function

$$\begin{aligned}\sin\sigma \sin(\gamma-g) = {} & \sin s \sin(\rho-r) \\ & -\chi \sin 1'' \cos s \sin(g-r)\cos(\rho-r) \\ & +\chi \sin 1'' \cos s \cos(g-r)\sin(\rho-r) \\ & +\frac{\chi^2}{2}\sin^2 1'' \sin s\,[\cos(g-r)\sin(g-r)\cos(\rho-r) \\ & \qquad -\cos^2(g-r)\sin(\rho-r)]\end{aligned}$$

Neglecting powers of χ that are higher than the second, we get

$$\begin{aligned}\sin\sigma \sin(\gamma-g) = {} & (\rho-r)\sin 1'' \sin s - \chi \sin 1'' \cos s \sin(g-r) \\ & +\chi \sin 1'' \cos s \cos(g-r) . (\rho-r)\sin 1'' \\ & +\frac{\chi^2}{2}\sin^2 1'' \sin s \cos(g-r)\sin(g-r) \ldots.\end{aligned}$$

If we multiply I_2 by $\sin(g-\rho)$ and I_3 by $\cos(g-\rho)$ and add the equations, we obtain after a similar development as given just before

$$\begin{aligned}\sin\sigma \cos(\gamma-g) = {} & \sin s + \chi \sin 1'' \cos s \cos(g-r) \\ & + \chi \sin 1'' \cos s \sin(g-r)(\rho-r)\sin 1'' \\ & - \frac{\chi^2}{2}\sin^2 1'' \sin s \cos^2(g-r) - \sin s \frac{(\rho-r)^2}{2}\sin^2 1''\end{aligned}$$

We now divide the last two equations by each other, and divide the right side by $\sin s$; then developing the denominator by the binomial theorem, we shall obtain the following result, which is correct to terms of the square of χ.

$$\begin{aligned}\gamma-g = {} & (\rho-r) - \chi \operatorname{cotg} s \sin(g-r) \\ & - \chi^2 \sin 1'' \operatorname{cotg} s \cos(g-r) \operatorname{cotg}\varphi \sin r \\ & + \frac{\chi^2}{2}\sin 1'' \cos(g-r)\sin(g-r) \\ & + \chi^2 \sin 1'' \operatorname{cotg} s \cos(g-r) \operatorname{cotg}\varphi \sin r \\ & + \chi^2 \sin 1'' \operatorname{cotg}^2 s \cos(g-r)\sin(g-r) \quad \text{or}\end{aligned}$$

$$\gamma-g = \rho-r-\chi \operatorname{cotg} s \sin(g-r)^{*} + \frac{\chi^2}{2}\sin 1'' \cos(g-r)\sin(g-r)(1+2\operatorname{cotg}^2 s) \qquad (\mathrm{II}_3)$$

For our further applications it will be sufficient to retain only terms of the first power in χ, we shall therefore apply the following formulas:

$$\left.\begin{aligned}\sigma-s &= \chi \cos(r-g) \ldots. \\ \rho-r &= -\chi \operatorname{cotg}\varphi \sin r \ldots. \\ \gamma-g &= \rho-r+\chi \operatorname{cotg} s \sin(r-g) \ldots.\end{aligned}\right\} \qquad (\mathrm{II})$$

II. *The derivation of the formulas of precession.*

We shall now apply the formulas (II) for the determination of the change, which the equatorial or ecliptical coordinates of a star undergo by the effect of precession. Adopting NEWTON's geometrical representation we say that the effect of perturbation of a body A upon another body B is such, that the pole of the orbit of B tends to describe a circle around the pole of the orbit of A. The rotatory motion of the *Earth* is especially influenced by the perturbations of *Moon* and *Sun*, the pole P of the equator will therefore tend to describe approximately a circle around E the pole of the ecliptic. The secular terms in the perturbing function of *Moon* and *Sun* we call luni-solar precession. But the translatory motion of the *Earth* around the *Sun* undergoes perturbations from the other planets, especially from *Venus* and *Jupiter*. Under the influence of these actions the pole E will tend to describe separately a circle around the pole of each of the perturbing bodies. This effect we call the planetary precession. We will study first the effect of the precession upon the equatorial coordinates of a star during the interval of time $T_2 - T_1$.

(a) *The equatorial coordinates.*

It seems at first as if our formulas (II) could not be applied for our equatorial system, since in our deductions above W was supposed to rest unchanged. But E which here takes the place of W changes during $T_2 - T_1$ from E_1 to E_2. This difficulty will be easily overcome, since by a mere algebraic addition we may go over from the coordinate γ that is counted from PE_0 to the coordinate γ that is counted from PE.

We identify I with P_1, V with P_2, W with E_0, where the indices express the times T_0, T_1, T_2, to which the position of the poles belong. For our further deductions we need also the points E_1 and E_2. When tracing a figure we shall have to locate P_1 and P_2 and E_1 and E_2 upon the same side of the great circle that passes through P_0 and E_0. The arcs P_0P_1 and P_1P_2 are relatively large with respect to E_0E_1 and E_1E_2. If not stated otherwise we shall always suppose that the arc combining two of these points with each other is an arc of a great circle. The arcs combining a point P with a point E will represent a certain value of the obliquity of the ecliptic. From our figure we learn that

$P_0E_0P_1 = p^0_{01}$ is the luni-solar precession during $T_1 - T_0$
$P_0E_0P_2 = p^0_{02}$ " " " " $T_2 - T_0$

---

[*] I find in my notes that Prof. FOERSTER has given a somewhat different expression for $\gamma - g$, namely,

$$\gamma - g = \rho - r + \chi \operatorname{cotg} s \sin(r-g) + \tfrac{1}{2}\sin 1'' \chi^2 \sin(r-g)\cos(r-g)$$

Since the derivation of this equation from the original equations has not been given in the lectures I presume that probably a mistake in writing has occurred.

$E_0 P_0 E_1 = q_0^{01}$ is the planetary precession during $T_1 - T_0$
$E_0 P_0 E_2 = q_0^{02}$ " " " " $T_2 - T_0$

The indices of the quantities p and q are chosen so that the upper indices refer always to the position of the pole of the ecliptic, the lower ones to that of the pole of the equator.

The values for p and q are given for the epoch T_0 by Celestial Mechanics; they are given in the form of a power series, the variable being t, that is $= T - T_0$ where T designates any time whatever.

The coordinates (s, g) and (σ, γ) of a point S are here

$$\left.\begin{array}{l} IS = P_1S = s = 90 - \delta_1 \\ VS = P_2S = \sigma = 90 - \delta_2 \end{array}\right\} \sigma - s = \delta_1 - \delta_2$$

$$\left.\begin{array}{l} WIS = E_0P_1S = g = 90 + \alpha_1 + q_1^{01} \\ WVS = E_0P_2S = \gamma = 90 + \alpha_2 + q_2^{02} \end{array}\right\} \gamma - g = \alpha_2 - \alpha_1 + (q_2^{02} - q_1^{01})$$

The auxiliary quantities are

$$WIN = E_0P_1N = r, \quad WVN = E_0P_2N = \rho, \quad IV = P_1P_2 = \chi$$

Since from Celestial Mechanics the quantities p and q, and the obliquity of the ecliptic $= \varepsilon$, are known, we may express χ, r, ρ by means of them.

In the triangle $E_0P_1P_2$ we have

The three sides	The three angles
$P_1P_2 = \chi$	$E_0P_1P_2 = r - 180$
$P_1E_0 = \varepsilon_1^0$	$E_0P_2P_1 = 360 - \rho$
$P_2E_0 = \varepsilon_2^0$	$P_1E_0P_2 = p_{02}^0 - p_{01}^0$

Applying Gauss's equations we obtain

$$\left.\begin{array}{rcl} \cos\left(\frac{\rho - r}{2}\right)\cos\frac{1}{2}\chi &=& \cos\left(\frac{p_{02}^0 - p_{01}^0}{2}\right)\cos\left(\frac{\varepsilon_1^0 - \varepsilon_2^0}{2}\right) \\ \sin\left(\frac{\rho - r}{2}\right)\cos\frac{1}{2}\chi &=& \sin\left(\frac{p_{02}^0 - p_{01}^0}{2}\right)\cos\left(\frac{\varepsilon_1^0 + \varepsilon_2^0}{2}\right) \\ -\cos\left(\frac{\rho + r}{2}\right)\sin\frac{1}{2}\chi &=& \cos\left(\frac{p_{02}^0 - p_{01}^0}{2}\right)\sin\left(\frac{\varepsilon_1^0 - \varepsilon_2^0}{2}\right) \\ -\sin\left(\frac{\rho + r}{2}\right)\sin\frac{1}{2}\chi &=& \sin\left(\frac{p_{02}^0 - p_{01}^0}{2}\right)\sin\left(\frac{\varepsilon_1^0 + \varepsilon_2^0}{2}\right) \end{array}\right\} (\mathrm{I}_a)$$

In our further developments we shall assume that the interval of time $T_2 - T_1$ is so, that we may be allowed to regard

$$p_{02}^0 - p_{01}^0 = dp_{01}^0$$
$$\varepsilon_2^0 - \varepsilon_1^0 = d\varepsilon_1^0$$

as differentials, and that all terms containing higher powers of χ than the first may be neglected. Under this assumption our formulas (I_a) become.

$$\left.\begin{array}{rcl} \cos\left(\frac{\rho - r}{2}\right) &=& 1 \\ \sin\left(\frac{\rho - r}{2}\right) &=& \frac{dp_{01}^0}{2}\sin 1''\cos\varepsilon_1^0 \\ \chi\cos\left(\frac{\rho + r}{2}\right) &=& d\varepsilon_1^0 \\ \chi\sin\left(\frac{\rho + r}{2}\right) &=& -dp_{01}^0\sin\varepsilon_1^0 \end{array}\right\} (2_a)$$

In our formulas (II) which we may now immediately apply, enter besides $\rho - r$ the quantities $\chi\sin r$ and $\chi\cos r$, which we have to determine from (2_a).

$$\chi\sin r = \chi\sin\left(\frac{\rho + r}{2} - \frac{\rho - r}{2}\right) = \chi\sin\frac{\rho + r}{2}\cos\frac{\rho - r}{2} - \chi\cos\left(\frac{\rho + r}{2}\right)\sin\left(\frac{\rho - r}{2}\right)$$

$$\chi\cos r = \chi\cos\left(\frac{\rho + r}{2} - \frac{\rho - r}{2}\right) = \chi\cos\frac{\rho + r}{2}\cos\frac{\rho - r}{2} + \chi\sin\frac{\rho + r}{2}\sin\frac{\rho - r}{2}$$

Introducing the above values, and neglecting terms which contain products or squares of the differentials, we get

$$\chi\sin r = -dp_{01}^0\sin\varepsilon_1^0$$
$$\chi\cos r = d\varepsilon_1^0$$

Introducing these values into (II) we obtain

$$\delta_2 - \delta_1 = d\delta_1 = d\varepsilon_1^0\sin(\alpha_1 + q_1^{01}) + dp_{01}^0\sin\varepsilon_1^0\cos(\alpha_1 + q_1^{01}) \ldots.$$
$$\alpha_2 - \alpha_1 = d\alpha_1 = -dq_1^{01} + dp_{01}^0\cos\varepsilon_1^0 + dp_{01}^0\sin\varepsilon_1^0\, tg\,\delta_1\sin(\alpha + q_1^{01})$$
$$- d\varepsilon_1^0\, tg\,\delta_1\sin\varepsilon\sin(\alpha + q_1^{01}) \ldots.$$

We can always assume that the epoch T_0 is not very distant from T_1. Since the q quantities are very small we may omit in the argument $\alpha_1 + q_1^{01}$ the quantity q_1^{01}. Since $\frac{d\varepsilon}{dt}$ according to the values of Peters and Struve is smaller than 0″.000015. we shall also suppress the terms containing this small quantity. Dividing both sides of our equations by dt, and suppressing the indices, we obtain the following general formulas

$$\frac{d\delta}{dt} = \frac{dp}{dt}\sin\varepsilon\cos\alpha \ldots.$$

$$\frac{d\alpha}{dt} = -\frac{dq}{dt} + \frac{dp}{dt}\cos\varepsilon + \frac{dp}{dt}\sin\varepsilon\, tg\,\delta\sin\alpha \ldots.$$

put

$$\frac{dp}{dt}\sin\varepsilon = n$$

$$-\frac{dq}{dt} + \frac{dp}{dt}\cos\varepsilon = m$$

and we obtain Bessel's formulas of precession.

$$\frac{d\delta}{dt} = n\cos\alpha$$

$$\frac{d\alpha}{dt} = m + n\, tg\,\delta\sin\alpha$$

In all those cases, where the star is very near to the pole — so that $tg\,\delta$ becomes a large multiplier — or where the interval of time $T_2 - T_1$ is large, it will be necessary to retain in (II) the terms multiplied by χ^2 and χ^3. Instead of the formulas (2_a) the exact formulas (1_a) will then have to be used.

(*b*) *The ecliptical coordinates.*

For this system we put

$$\begin{array}{lll} I = E_1 & IW = f = \varepsilon_0^1 & WIN = P_0E_1N = r \\ V = E_2 & VW = \phi = \varepsilon_0^2 & WVN = P_0E_2N = \rho \\ W = P_0 & & IV = E_1E_2 = \chi \end{array}$$

$$WIS = g = P_0E_1S = 360 - (P_0E_1P_1 + P_1E_1S)$$
$$= 360 - (90 - \lambda_1 + p_{01}^1)$$

$$WVS = \zeta = PE_2S = 360-(P_0E_2P_2+P_2E_2S)$$
$$= 360-(90-\lambda_2+p^2_{02})$$

$$g = 270+\lambda_1-p^1_{01} \qquad s = 90-\beta_1$$
$$\zeta = 270+\lambda_2-p^2_{02} \qquad \sigma = 90-\beta_2$$
$$\zeta-g = \lambda_2-\lambda_1-(p^2_{02}-p^1_{01}) \qquad \sigma-s = -(\beta_2-\beta_1)$$

In the triangle $P_0E_1E_2$.

The sides are	The angles are
$P_0E_1 = \varepsilon^1_0$	$P_0E_1E_2 = 180-r$
$P_0E_2 = \varepsilon^2_0$	$P_0E_2E_1 = \rho$
$E_1E_2 = \chi$	$E_1P_0E_2 = q^{02}_0-q^{01}_0$

Applying GAUSS's equations to this triangle, and putting

$$q^{02}_0-q^{01}_0 = dq^{01}_0$$
$$\varepsilon^2_0-\varepsilon^1_0 = d\varepsilon^1_0$$

we obtain approximately

$$(2_b)\quad\left\{\begin{aligned} \cos\left(\frac{\rho-r}{2}\right) &= 1\\ \sin\left(\frac{\rho-r}{2}\right) &= -\frac{dq^{01}_0}{2}\sin 1''\cos\varepsilon^1_0\\ \chi\cos\left(\frac{\rho+r}{2}\right) &= d\varepsilon^1_0\\ \chi\sin\left(\frac{\rho+r}{2}\right) &= dq^1_0\sin\varepsilon_0 \end{aligned}\right.$$

By means of (2_b) we could in the same manner as before express $\rho-r$, $\chi\sin r$, $\chi\cos r$. But to identify our formulas with those given by BESSEL in his *Tabulae Regiomontanae*, we shall proceed here in a somewhat different manner. From (11) we obtain

$$d\beta_1 = -\chi\sin(\lambda_1-r-p^1_{01})$$
$$d\lambda_1 = (p^2_{02}-p^1_{01})+\rho-r+\chi\, tg\beta_1\cos(\lambda_1-r-p^1_{01})$$

Let us assume a point N_0 upon the continuation of E_1E_0 beyond E_0, then is the angle $P_0E_0N_0 = \Pi_0$ = longitude of the ascending node of the ecliptic at the time T_1 upon that at the time T_0. Indeed, if we represent the equator and ecliptic at T_0 by great circles, and call the point of vernal equinox at T_0 = ♈$_0$, draw furthermore the ecliptic at T_1 which intersects that at T_0 in the points ☊ and ☋, we have ♈$_0$☊ $= \Pi_0$. But we see from our figure that

$$E_1E_0☊ = 90$$
$$♈_0E_0P_0 = 90$$
$$E_1E_0♈_0 = 90-\Pi_0$$
$$\therefore E_1E_0P_0 = 180-\Pi_0$$

but $\qquad E_1E_0P_0 = 180°-P_0E_0N_0$

therefore $\qquad P_0E_0N_0 = \Pi_0$.

In the same manner would follow $P_1E_1N_1 = \Pi_1$.

In the *Tabulae Regiomontanae* the value of Π_0 for a certain epoch (1750) is given by a series arranged according to powers of t. The transformation of Π_0 into Π_1 will consist of two parts; first a slight rotation of the great circle E_1E_0 around E_1 into the position E_2E_1, and further a change of the great circle E_1P_0 into the direction E_1P_1. The first increment arising from the slow change of the direction of the motion of the pole of the ecliptic, we shall designate by $\frac{d\Pi}{dt}(T_1-T_0)$, the second one arising from the motion of the pole P is p^1_{01}. From our figure we see that $\Pi_0+\frac{d\Pi}{dt}(T_1-T_0)$ is in value equal to r, therefore $r+p^1_{01} = \Pi_0+\frac{d\Pi}{dt}(T_1-T_0)+p^1_{01}$; introducing this value into our equations for $d\beta$ and $d\lambda$ we obtain

$$d\beta_1 = -\chi\sin\left(\lambda_1-\Pi_0-\frac{d\Pi}{dt}(T_1-T_0)-p^1_{01}\right)$$
$$d\lambda_1 = (p^2_{02}-p^1_{01})+\rho-r+\chi\, tg\beta_1\cos\left(\lambda_1-\Pi_0-\frac{d\Pi}{dt}(T_1-T_0)-p^1_{01}\right)$$

From the equations (2_b) we obtain

$$\rho-r = -dq^{01}_0\cos\varepsilon^1_0$$

The quantity χ is very small. We may designate it by $d\pi$; we put also $p^2_{02}-p^1_{01} = dp^1_{01}$

Calling $\qquad dp^1_{01}-dq^{01}_1\cos\varepsilon^1_0 = dl_1$

$$\Pi_0+\frac{d\Pi}{dt}(T_1-T_0)+p^1_{01} = M_1$$

we get
$$d\beta_1 = -d\pi\sin(\lambda_1-M_1)$$
$$d\lambda_1 = dl_1+d\pi\, tg\beta_1\cos(\lambda_1-M_1)$$

Dividing both sides by dt, and suppressing the indices, we obtain the general expressions for precession in the ecliptical coordinates,

$$\frac{d\beta}{dt} = -\frac{d\pi}{dt}\sin(\lambda-M)$$

$$\frac{d\lambda}{dt} = \frac{dl}{dt}+\frac{d\pi}{dt}tg\beta\cos(\lambda-M)\,.$$

The University of Chicago, 1895 March.

ON THE ANNUAL TERM OF THE LATITUDE-VARIATION FROM THE LYONS OBSERVATIONS,

BY S. C. CHANDLER.

In the arrangement and treatment of the observations which were the subject of the note in *A.J.* 334, the annual term was eliminated, and only the 428-day term was determined by GONNESSIAT. It seems to me important, however, to point out that his observations of *Polaris* furnish the means for a tolerable determination of the former. Thus, if we correct these for the 428-day term found from all his stars, by the formula in my note, adopt the value $\varDelta\delta = -0''.40$, and arrange the results according to the time of the year; then taking means which shall have approximately equal weight, we have the values of $\varDelta\varphi$ in column "O" below, the argument τ being the fraction of a year, corresponding to the sun's mean longitude in column 2.

τ	⊙	O	C
	°	″	″
0.096	314.6	−0.35	−0.13
.244	7.8	− .21	− .13
.325	37.0	− .08	− .04
.325	37.0	+ .16	− .04
.364	51.0	+ .11	+ .02
.392	61.1	− .06	+ .07
.415	69.4	+ 09	+ .12
0.429	71.4	+0.35	+0.17
0.612	140.3	+0.35	+0.38
.676	163.4	+ .43	+ .40
.830	218.8	− .17	+ .27
.870	233.2	+ .19	+ .21
.881	237.2	+ .70	+ .19
.907	246.5	+ .12	+ .14
.949	261.6	+ .12	+ .07
0.975	271.0	−0.09	+0.03

Solving by the methods of *A.J.* 287. we get the mean corrected latitude, $\varphi_0 = 45° \, 41' \, 41''.02$; and the values of the other unknowns,

$$Y = +0''.088 \pm 0''.057 \quad . \quad Z = -0''.262 \pm 0''.069$$

which are referred to STRUVE's constant of aberration. Reducing them to the value 20″.500 by means of eq. (28), we derive the constants of the annual term,

$$G' = 351°.7 \pm 14°.2 \quad , \quad r_2 = 0''.249. \pm 0''.065$$

Referring the epoch to Greenwich, and adding the 428-day term found in *A.J.* 334, we have the full expression for the latitude-variation, as found by GONESSIAT's observations, 1885–93,

$$\varphi - \varphi_0 = -0''.175 \cos(t - 2410936)\theta - 0''.249 \cos(⊙ - 347°)$$

Equation (52) gives, for the average epoch 1889,

$$\varphi - \varphi_0 = -0''.174 \cos(t - 2410912)\theta - 0''.147 \cos(⊙ - 344°)$$

The agreement is exceedingly good, except for the amplitude of the annual term, but the probable error of this is large, as will be seen above.

The values in column "C" of the table were computed by means of the Y and Z given above, with $X = +0''.12$.

Cambridge, 1895 *January* 17.

PLACES OF COMPARISON-STARS FOR COMET *e* 1894 = 1894 IV,

BY HERBERT A. HOWE.

The following places of comparison-stars used in my observations of Comet *e* 1894. have been carefully determined by micrometric connection with well determined stars. The numbers in the first column correspond to those used in *A.J.* 333 and 334.

Mean Places 1894.0.

*	α	δ	Authority.		
	h m s	° ′ ″		m s	′ ″
1	22 45 42.21	−10 6 56.1	Foll. A.G.C. 31007	4 56.71,	8 16.2 north.
3	23 34 28.32	− 3 56 12.2	Prec. Brussels 10616	3 40.80.	2 11.4 south.
4	23 37 11.72	− 3 32 42.2	Foll. Lalande 46315,6	3 49.71,	0 1.8 north.
6	23 42 25.75	− 2 53 31.8	Foll. Radcliffe (1890) 6339	3 25.92,	9 9.8 north.
8	23 48 15.35	− 2 14 56.5	Prec. Brussels 10730	4 50.68,	1 33.0 north.
9	23 55 26.95	− 1 16 14.1	Prec. A.G.C. 32426	1 10.68,	10 45.9 south.
10	0 11 20.97	− 0 32 59.7	Foll. Munich (1880) 87	3 31.56,	0 25.3 north.

MEAN DECLINATIONS AND PROPER MOTIONS OF FIFTY-SIX STARS (*ASTR. GES. CATAL.* SYSTEM. *ASTR. NACHR.* 3195–96),

BY HERMAN S. DAVIS.

[Communicated by J. K. REES, Director.]

In 1893 the Astronomical Department of Columbia College instituted, under the directorship of Professor J. K. REES, a systematic series of observations of twenty-eight pairs of stars by the Talcott method in cooperation with Professor FERGOLA of Naples, having in view a discussion of the variation of latitude, and a redetermination of the constant of aberration by KÜSTNER's method.

It was designed from the beginning to base the reductions of latitude on declinations deduced from all accessible data, and the present paper contains the final results of this investigation. A detailed exposition of the data and of the methods is to be published soon in the Memoirs of the New York Academy of Sciences, but that the positions here given may be at once available, it was thought advisable to publish this article in advance of the more detailed work.

The magnitude, the right-ascension, and the proper motion in right-ascension, are compiled from the *A.G.C. Fundamental-Catalog*, ROMBERG, *Pulkowa* 1855, *Greenwich Ten-Year*, or SAFFORD's 2018 *Stars*: all other quantities in the table have been computed from one hundred and twenty-nine various catalogues or separate series of Annual Results.

The positions are given for the epoch 1875.0, brought up from the mean date of observation by the proper motion here computed, and may be reduced to another epoch t by the formulas

$\alpha_t = \alpha_{1875} + J(t-1875) + K\frac{(t-1875)^2}{200}$ approximately. $\delta_t = \delta_{1875} + L(t-1875) + M\frac{(t-1875)^2}{200} + N\left(\frac{t-1875}{100}\right)^3.$

Star	Mag.	α 1875	Ann. Var. J	Secular Variation K	Annual Proper Motion	Date 1800+	No. Obs.	No Cat.	δ 1875	Prob. Error	Wt.	Corr. Ann. Var. L	Sec. Var. M	Third Term N	Annual Proper Motion	Prob. Error
		h m s	s	s	s				° ′ ″	″		″	″	″	″	″
F.10 *Camelop.*	4.0	4 52 18.38	5.3107	+0.0419	0.0000	66.24	427	37	60 15 22.866	±0.051	74.6	+ 5.8214	—.744	—.231	—0.0166	±.0022
ι *Tauri* 102	5.0	4 55 37.51	3.5799	+ .0091	+ .0040	59.32	366	45	21 24 33.418	.062	66.6	+ 5.5254	—.505	—.078	— .0336	23
λ *Aurigae* 15	5.0	5 10 21.05	4.2120	+ .0121	+ .0147	63.06	231	33	39 59 7.306	.072	40.3	+ 3.6569	—.608	—.087	— .6541	28
ρ *Aurigae* 20	5.8	5 12 57.62	4.2382	+ .0134	+ .0007	51.91	66	15	41 40 37.881	.166	10.9	+ 4.0461	—.607	—.088	— .0409	48
F.17 *Camelop.*	6.0	5 18 22.13	5.6473	+ .0313	— .0012	68.57	173	19	62 57 33.609	.073	33.0	+ 3.6127	—.812	—.165	— .0103	27
F.119 *Tauri*	5.0	5 21 53.07	3.5140	+ .0056	— .0003	61.11	143	28	18 29 56.730	.088	28.2	+ 3.0649	—.508	—.039	+ .0039	32
ξ *Aurigae* 30	5.0	5 44 22.21	5.0207	+ .0088	— .0050	56.23	106	19	55 40 29.184	.108	19.2	+ 1.3851	—.730	—.041	+ .0181	30
F.139 *Tauri*	5.3	5 50 14.27	3.7219	+ .0031	.0000	59.99	118	30	25 56 9.812	.091	27.2	+ 0.8617	—.543	—.010	— .0103	32
F.2 *Lyncis*	4.6	6 8 35.58	5.3005	— .0039	+ .0001	62.11	234	28	59 3 10.156	.065	51.6	— 0.7290	—.772	+.039	+ .0230	33
μ *Geminor.* 13	3.0	6 15 23.89	3.6305	— .0005	+ .0037	63.09	1748	59	22 34 31.900	.041	137.7	— 1.4506	—.528	+.025	— .1046	17
ν *Geminor.* 18	4.6	6 21 32.44	3.5621	— .0009	— .0022	60.93	329	37	20 17 20.780	.068	47.5	— 1.8931	—.516	+.030	— .0111	24
F 8 *Lyncis*	6.0	6 26 15.72	5.4934	— .0185	— .0340	61.91	184	22	61 35 15.588	.074	35.2	— 2.5711	—.790	+.118	— .2781	27
ζ *Geminor.* 43	var.	6 56 41.66	3.5623	— .0051	— .0011	63.61	744	47	20 45 5.658	.046	101.1	— 4.9071	—.502	+.074	+ .0039	21
F.17 *Lyncis*	7.0	6 58 25.41	5.4028	— .0367	— .0021	61.90	158	20	60 59 8.508	.094	23.5	— 5.1055	—.760	+.228	— .0485	30
Pi. XII. 255	6.	12 56 53.80	2.3632	— .0271	— .0270	63.91	75	14	64 16 55.500	.126	14.0	—19.4281	+.092	+.077	+ .0109	57
Pi. XII. 283	6.7	13 3 39.15	2.9566	— .0030	.0000	63.62	40	10	17 30 56.709	.176	7.8	—19.2849	+.126	+.145	+ .0011	86
F.20 *Can. Ven.*	4.6	13 11 56.14	2.6976	— .0130	— .0129	62.76	191	28	41 13 52.193	.074	40.4	—19.0565	+.129	+.110	+ .0175	30
F.23 *Can. Ven.*	5.6	13 11 42.77	2.6972	— .0125	— .0054	47.34	54	17	40 48 25.799	.170	10.3	—19.0064	+.134	+.110	— .0084	41
F.83 *Ursae Maj.*	5.4	13 35 59.70	2.2803	— .0120	— .0062	59.84	151	22	55 18 53.416	.093	27.1	—18.3243	+.143	+.071	— .0033	33
F.3 *Bootis*	6.0	13 40 54.99	2.7867	— .0038	— .0035	64.81	115	17	26 19 48.062	.095	22.0	—18.2029	+.181	+.124	— .0619	36
υ *Bootis* 5	4.3	13 43 26.87	2.8911	+ .0001	— .0093	64.43	151	22	16 25 7.516	.081	30.0	—17.9975	+.191	+.130	+ .0485	30
i *Draconis* 10	5.0	13 47 46.91	1.7509	+ .0003	— .0017	64.79	307	30	65 20 28.659	.063	52.1	—17.8793	+.123	+.046	— .0023	26
α *Draconis* 11	3.3	14 1 0.35	1.6203	+ .0051	— .0092	64.91	2034	52	64 58 25.659	.043	112.3	—17.3135	+.126	+.044	+ .0105	19
20 *Bootis*	5.0	14 13 50.29	2.8376	+ .0015	— .0110	62.32	118	23	16 52 49.744	.092	24.2	—16.6671	+.234	+.116	+ .0639	33
Pi. XIV. 156	6.0	14 34 17.27	1.9008	+ .0010	.0000	54.71	79	16	54 33 51.853	.160	12.5	—15.6785	+.180	+.049	+ .0005	55
F.34 *Bootis*	5.2	14 37 55.76	2.6369	.0000	— .0011	60.46	121	23	27 3 36.690	.096	23.0	—15.4813	+.251	+.089	— .0033	32
Pi. XIV, 178	–	14 40 12.70	2.8311	+ .0030	.0000	53.30	37	11	15 39 28.971	.202	7.6	—15.3318	+.272	+.109	+ .0182	64
2 H. *Urs. min.*	5.0	14 55 36.13	0.9398	+ .0281	— .0074	70.75	175	19	66 25 50.798	.069	36.6	—14.4124	+.100	+.048	+ .0376	39
ζ *Draconis* 22	3.0	17 8 25.72	0.1604	+ .0192	— .0027	65.39	529	38	65 52 7.124	.050	81.8	— 4.4574	+.024	+.042	+ .0186	21
Pi. XVII, 94	6.1	17 18 55.75	2.7020	+ .0032	.0000	45.22	34	8	15 43 16.331	.259	7.2	— 3.5577	+.389	+.025	+ .0173	69
λ *Herculis* 76	4.8	17 25 41.17	2.4216	+ .0028	— .0002	60.73	187	25	26 12 22.406	.084	31.4	— 2.9615	+.350	+.017	+ .0295	30
ν′ *Draconis* 24	4.7	17 29 42.95	1.1787	+ .0055	+ .0183	65.16	202	33	55 16 13.081	.060	54.0	— 2.5941	+.174	+.014	+ .0479	24
z *Herculis* 88	6.0	17 46 47.08	1.5780	+ .0032	+ .0006	63.00	115	19	48 25 43.411	.093	23.3	— 1.1382	+.229	+.007	+ .0178	32
Pi XVII, 347	6.1	17 56 1.67	2.1969	+ .0023	.0000	65.78	38	10	33 13 9.913	.147	9.1	— 0.3601	+.320	+.003	— .0131	62
b *Herculis* 99	5.0	18 2 16.83	2.2744	+ .0021	— .0089	57.43	114	18	30 32 42.835	.105	23.2	+ 0.2733	+.330	—.001	+ .0743	36
Groomb. 2549	6.3	18 17 0.48	1.4084	+ .0016	.0000	59.74	79	14	51 17 36.321	.116	18.6	+ 1.4360	+.204	—.002	— .0510	45
F.42 *Draconis*	5.1	18 25 37.39	0.1746	— .0045	+ .0158	60.17	155	21	65 29 10.324	.091	27.0	+ 2.2075	+.027	—.011	— .0295	30
Pulk. 2621	6.4	18 31 32.59	2.6902	+ .0012	.0000	67.27	28	6	16 5 33.331	.165	7.0	+ 2.8106	+.387	—.020	+ .0596	76
Groomb. 2658	6.0	18 39 50.60	0.5291	— .0060	.0000	65.18	55	11	62 37 31.854	.137	11.0	+ 3.5118	+.074	—.016	+ .0428	61
Pi. XVIII, 203	5.9	18 43 26.0	2.6153	+ .0011	.0000	57.44	31	9	19 11 24.217	.209	6.4	+ 3.7735	+.373	—.025	— .0045	76
F.48 *Draconis*	6.0	18 54 38.16	1.0168	— .0037	— .0054	53.14	226	23	57 38 58.550	.094	29.7	+ 1.6728	+.141	—.015	— .0632	26
Bradley 2409	5.4	19 1 25.64	2.4917	+ .0010	+ .0050	61.02	51	15	24 3 29.697	.137	12.5	+ 5.3213	+.350	—.032	+ .0103	53
f′ *Cygni* 59	5.3	20 55 34.46	2.0387	+ .0031	+ .0009	58.36	222	27	47 2 1.143	.076	41.3	+13.9045	+.208	—.048	+ .0005	25
υ *Cygni* 66	4.5	21 12 46.73	2.4622	+ .0049	— .0005	57.78	120	23	34 22 22.158	.100	23.0	+14.9467	+.233	—.075	— .0023	33
F.70 *Cygni*	5.1	21 22 15.56	2.4421	+ .0059	.0000	58.61	101	19	36 34 27.286	.121	17.7	+15.5046	+.220	—.075	+ .0156	45
ρ *Cygni* 73	4.1	21 29 16.80	2.2505	+ .0072	— .0034	56.33	132	23	45 2 23.302	.099	22.8	+15.7767	+.194	—.058	— .0953	27
F.16 *Pegasi*	5.3	21 47 22.54	2.7255	+ .0053	— .0005	69.75	835	41	25 20 15.817	.045	92.5	+16.7936	+.210	—.106	+ .0046	29
F.13 *Cephei*	6.1	21 50 41.12	2.0084	+ .0080	— .0030	58.45	180	18	56 1 10.983	.099	26.2	+16.9318	+.149	—.051	— .0112	36
Pi. XXI, 405	5.3	22 0 58.29	2.4222	+ .0112	.0000	60.13	49	12	44 24 24.279	.155	10.1	+17.3808	+.168	—.079	— .0292	58
F.1 *Lacertae*	4.6	22 10 31.28	2.6066	+ .0108	— .0004	59.84	130	20	37 7 36.349	.106	19.8	+17.8169	+.167	—.097	+ .0079	35
F.25 *Cephei*	6.1	22 14 8.02	1.9450	+ .0107	+ .0018	53.66	77	15	62 10 41.109	.146	14.2	+17.9568	+.119	—.050	+ .0048	46
F.39 *Pegasi*	6.0	22 26 33.09	2.8922	+ .0058	+ .0086	59.38	100	20	19 35 10.771	.113	17.2	+18.4387	+.160	—.132	+ .0287	36
Groomb. 3919	6.1	22 48 22.90	2.7308	+ .0166	.0000	68.16	65	14	39 42 39.015	.119	13.4	+19.1355	+.114	—.115	+ .0525	60
o *Andromedae* 1	3.6	22 56 10.39	2.7160	+ .0187	+ .0007	66.77	343	36	41 39 16.161	.054	65.0	+19.2710	+.102	—.117	— .0110	24
F.2 *Cassiopeae*	5.8	23 1 23.78	2.5450	+ .0304	+ .0001	50.95	71	16	58 39 18.220	.133	16.7	+19.4651	+.081	—.095	— .0019	36
υ *Pegasi* 68	4.6	23 19 8.52	2.9842	+0.0113	+0.0112	64.49	231	29	22 42 58.030	±0.068	44.3	+19.7729	+.069	—.152	+ .0369	±.0029

Columbia College Observatory, New York City, 1895 *March* 8.

OBSERVATIONS OF ENCKE'S COMET,

MADE AT THE U.S. NAVAL OBSERVATORY,

BY PROF. E. FRISBY, U.S.N.

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

1895 Washington M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Jan. 17 7 25 45.5	1	5 , 1	+0 30.01	+7 28.8	21 57 38.02	−1 18 5.3	9.655	0.745
7 25 45.5	2	5 , 1	−1 41.28	+6 45.3	21 57 38.27	−1 18 10.5	9.655	0.745
19 7 22 51.0	3	16 , 4	−0 16.68	−4 28.7	21 52 36.31	−2 24 17.5	9.658	0.745

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 57 8.81	−0.80	−1 25 27.2	−6.9	½(Bonn VI+Copeland-Börgen.)
2	21 59 23.35	−0.80	−1 24 49.0	−6.8	W. Mun., Gr. 1870, Sj., Yarnall
3	21 52 53.80	−0.81	−2 19 41.5	−7.3	Munich

FILAR-MICROMETER OBSERVATIONS OF ASTEROID (16), *PSYCHE.*

MADE WITH THE 12-INCH EQUATORIAL OF THE DETROIT OBSERVATORY, ANN ARBOR, MICHIGAN.

BY SIDNEY D. TOWNLEY.

[Communicated by the Director of the Observatory.]

1894 Ann Arbor M.T.	*	No. comp.	Planet — *		Planet's Apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
July 8 11 52 20	1	10 , 6	−4 7.99	−0 15.1	20 35 12.57	−16 11 8.1	n9.260	0.867
12 11 46 10	2	10 , 6	+0 56.59	−0 10.1	20 32 22.96	−16 23 54.8	n9.202	0.870
14 11 20 38	2	12 , 6	−0 32.44	−6 51.6	20 30 53.97	−16 30 36.1	n9.277	0.867
21 10 18 51	3	12 , 6	−1 11.87	+2 13.1	20 25 22.79	−16 55 45.6	n9.381	0.862
10 57 58	4	12 , 6	+0 38.70	−1 42.7	20 25 21.31	−16 55 48.2	n9.232	0.871
22 10 37 23	3	12 , 6	−2 1.76	−1 34.8	20 24 32.90	−16 59 33.5	n9.300	0.868
29 10 9 23	5	12 , 6	+0 12.59	−2 0.6	20 18 42.27	−17 26 26.5	n9.279	0.871
Aug. 2 10 55 9	7	12 , 6	−0 42.63	−0 50.8	20 15 21.07	−17 41 54.3	n8.821	0.879
4 10 11 15	9	12 , 8	−0 23.18	+0 15.9	20 13 44.23	−17 49 28.1	n9.126	0.878
5 10 14 33	9	12 , 6	−1 11.58	−3 32.6	20 12 55.83	−17 53 16.6	n9.073	0.880

Mean Places for 1894.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	20 39 17.47	+3.09	−16 10 57.4	+4.4	½ (Munich I. 25822+Munich II. 10755)
2	20 31 23.19	+3.18 +3.22	−16 23 48.7	+4.0 +4.2	½ (Munich I. 25238+Munich II. 10540)
3	20 26 31.30	+3.36	−16 58 2.9	+4.2	⅓(Oe.A. 20592,3 + Cape 1850,4071 + Gould 28145)
4	20 24 39.25	+3.36	−16 54 9.5	+4.0	Oeltzen's Argelander 20559
5	20 18 26.22	+3.46	−17 24 29.8	+3.9	Micrometer-determination from 6
6	20 18 30.05		−17 21 8.5		Oeltzen's Argelander 20475
7	20 16 0.18	+3.52	−17 41 7.2	+3.7	Micrometer-determination from 8
8	20 20 29.45		−17 43 20.6		Oeltzen's Argelander 20499
9	20 14 3.88	+3.53	−17 49 47.5	+3.5	Oeltzen's Argelander 20409

ASTRONOMICAL JOURNAL PRIZES.

Report of the Judges.

The undersigned desire respectfully to recommend that the *Astronomical Journal* Prize, No. I. of 1895 — of $200 to the observer, a resident citizen of the United States, making the best series of determinations of maxima and minima of variable stars, by Argelander's method, during the two years ending 1895 March 31 (*A.J.* 288) — be awarded to Mr. Paul S. Yendell, of Dorchester, Mass.

Asaph Hall.
Lewis Boss.
S. C. Chandler.

1895 *April* 8.

In sending this award the Judges write that they take the opportunity to congratulate Mr. Yendell on the great amount and excellence of the work which, as a volunteer observer, he has accomplished. The prize has accordingly been transmitted to Mr. Yendell. — Ed.

ASTRONOMICAL JOURNAL PRIZES.

Report of the Judges.

The undersigned respectfully submit the following statement concerning the *Astronomical Journal* Prize No. II. for 1895 — of $100 "For the most thorough discussion of the theory of the rotation of the Earth, with reference to the recently discovered variations of latitude."

One manuscript was received within the prescribed time, and therefore only this could be considered. The merit of this paper, however, appears to be such as to justify the award to its author, Professor Simon Newcomb, of Washington, D.C.

Asaph Hall.
Lewis Boss.
S. C. Chandler.

1895 *April* 17.

The prize has accordingly been transmitted to Prof. Newcomb. — Ed.

NOMENCLATURE OF ASTEROIDS.

The following names have been assigned to small planets by their discoverers.

No. 318	Charlois	1891 Sept. 24	*Magdalena*
319	"	1891 Oct. 8	*Leona*
331	"	1892 Apr. 1	*Etheridgea*
336	"	1892 Sept. 19	*Lacadiera*
384	Courty	1894 Feb. 11	*Burdigala*

Mr. Berberich finds the asteroid *BV* to be (203) *Pompeia*, for which the place at opposition, as given in the Berlin *Jahrbuch*, was affected by a numerical error.

CORRIGENDA TO APPENDIX IN THE CORDOBA ZONE-CATALOGUE.

Prof. Krueger has pointed out that in the tables for computing the third term of the precession, appended to the two volumes of the Zone-Catalogue, pages (38) and (39), the values of P_3 should be multiplied by the factor 2.

Also two typographical errors on p. (6), where the factor of the first term of P_2 should be $\cos 2a$, instead of $\cos^2 a$, and the first term of Q_1 should be negative. These errors do not affect the tables.

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Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed May 3.*

THE
ASTRONOMICAL JOURNAL.
No. 345.

VOL. XV. BOSTON, 1895 MAY 21. NO. 9

MECHANICAL INTERPRETATION OF THE VARIATIONS OF LATITUDES,

BY R. S. WOODWARD.

1. *Statement of problem.* The problem of the variations of terrestrial latitudes is one of the most important of those at present confronting astronomers. On the one hand, most classes of precise astronomical observations are subject to grave discrepancies arising from such variations, so that a knowledge of their nature and extent is indispensable. It is, indeed, now essential to revise Laplace's dictum[1] of the early part of this century and make it read, "all astronomy rests on a knowledge of the variations of latitude." On the other hand, those variations are regarded as raising grave difficulty for the dynamical astronomers. Most of the latter have been seriously puzzled, it must be admitted, by the peculiar character of the variation which has been so thoroughly fortified by the indefatigable labors of Dr. CHANDLER. Nothing, certainly, could be more disturbing than the necessity of explaining an increase in the Eulerian circle from 305 to 428 days.

Having given some attention to this problem from the mechanical point of view, I have thought it proper to offer this paper for publication, hoping that it may assist in clearing up the difficulties which lie in the way of a satisfactory solution, if it cannot be judged as having attained this desirable end.

Assuming that the variations in question are not due to causes external to the earth, the problem requires that we look to the kinetics of the earth itself for an adequate explanation of those variations. It is necessary, therefore, to start with the comprehensive hypothesis that the earth is a body of variable form, or at least that some portions of the earth's mass are subject to changes in relative position.

The mechanical theory of rotating bodies of variable form is generally credited to LIOUVILLE, whose classic memoir[2] on this subject was published in 1858. It appears, however, that LAGRANGE had considered the subject long before, for his posthumous "Fragments" published as additions to the second volume of his *Mécanique Analytique* (2d ed., 1815, and later editions) contain a theory of such bodies from his characteristic point of view, which is that supplied by what we now call the doctrine of energy.

In applying this theory to the case presented by the earth, much progress has been made by GYLDÉN[1], DARWIN[2], HELMERT[3], TISSERAND[4], and others. The fundamental differential equations of the problem may be regarded as settled. The work which remains to be done consists chiefly in discovering from the wide variety of possible integrals of those equations, the particular integrals applicable to the actual circumstances of the earth. It will not be essential therefore to go far into the details of the mechanics which lead up to the fundamental equations, such details being admirably worked out in the treatises of HELMERT and TISSERAND just cited. At the same time, it seems desirable, by reason of the great interest in the problem, to indicate briefly all of the important steps of the investigation.

2. *Derivation of equations of rotation.* The process followed by LIOUVILLE and favored by all later writers, so far as I am aware, in deriving the equations of rotation of a body of variable form, consists in transforming D'ALEMBERT's equations of rotation so as to refer them to coordinate axes which are movable in any manner. The process I have followed is that of LAGRANGE, which enables us to set down the equations of motion of a dynamical system when its kinetic energy is known. The resulting expressions are the same as those of LIOUVILLE; but the Lagrangian process is so much more in accord with current views of dynamical questions that an outline of it will not be out of place here.

---

[1] "*Toute l'Astronomie repose sur l'invariabilité de l'axe de rotation de la Terre à la surface du spheröide terrestre.*" *Mécanique Celeste*, Tome V, p. 22.

[2] *Développements sur un Chapitre de la Mécanique de Poisson. Par* M. J. LIOUVILLE. *Journal de Mathématiques Pures et Appliquées. Deuxième série*, Tome III, 1858. The same memoir was published in 1857 in the *Additions à la Connaissance des Temps*, for 1859.

[1] *Recherches sur la Rotation de la Terre. Par* H. GYLDÉN. Proceedings Royal Society of Sciences of Upsal, 1871.

[2] On the Influence of Geological Changes on the Earth's Axis of Rotation. Philosophical Transactions, Vol. CLXVII, 1877.

[3] *Die Mathematischen und Physikalischen Theorieen der Höheren Geodäsie*, II Theil. B. G. TEUBNER, Leipzig, 1884.

[4] *Traité de Mécanique Céleste*, Tome II. GAUTHIER-VILLERS ET FILS, Paris, 1891.

In what follows we are concerned solely with the question of rotation. It is assumed to be independent of the motion of translation of the body as a whole. This is evidently justifiable in the case of the earth, though it might not be in the case of bodies moving in more highly curved orbits.

Imagine a system of rectangular coordinate axes originating at the centroid of the body. Denote an element of mass of the body by m, and let its position be defined by the coordinates x, y, z at any time t. With respect to the positions occupied by the axes of x, y, z at this time, the displacement of m during the following element of time dt may be conceived as arising from the rotation of the body as a whole about its instantaneous axis, and from the change in form of the body. Calling the component angular velocities about the several axes ω_x, ω_y, ω and denoting the component displacements due to change of form by dx_1, dy_1, dz_1, respectively, the velocities of displacement of m will be given by the following equations:

$$
(1)\qquad
\begin{aligned}
\frac{dx}{dt} &= \frac{dx_1}{dt} + z\omega_y - y\omega_z \\
\frac{dy}{dt} &= \frac{dy_1}{dt} + x\omega_z - z\omega_x \\
\frac{dz}{dt} &= \frac{dz_1}{dt} + y\omega_x - x\omega_y
\end{aligned}
$$

Writing for brevity

$$
(2)\qquad
\begin{aligned}
x' &= \frac{dx}{dt}\,, & y' &= \frac{dy}{dt}\,, & z' &= \frac{dz}{dt} \\
x'_1 &= \frac{dx_1}{dt}\,, & y'_1 &= \frac{dy'_1}{dt}\,, & z'_1 &= \frac{dz_1}{dt}
\end{aligned}
$$

and denoting the kinetic energy by T, we have

$$
(3)\qquad T = \tfrac{1}{2}\Sigma m\,(x'^2+y'^2+z'^2)
$$

Let us now choose as the axes of reference the principal axes of inertia of the body at the time t. Let the principal (variable) moments of inertia be denoted by A, B, C; A being the least, and C the greatest of them; and, as usual, let them refer to the axes of x, y, z, respectively. Then with the following abbreviations

$$
(4)\qquad
\begin{aligned}
f &= \Sigma m\,(yz'_1 - zy'_1) \\
g &= \Sigma m\,(zx'_1 - xz'_1) \\
h &= \Sigma m\,(xy'_1 - yx'_1)
\end{aligned}
$$

$$
(5)\qquad T_1 = \tfrac{1}{2}\Sigma m\,(x'^2_1+y'^2_1+z'^2_1)
$$

equations (1) and (3) give

$$
(6)\qquad
\begin{aligned}
T = {} & \tfrac{1}{2}(A\omega_x^2 + B\omega_y^2 + C\omega_z^2) \\
& + \omega_x f + \omega_y g + \omega_z h + T_1
\end{aligned}
$$

The last equation gives the kinetic energy of the system with respect to the instantaneous positions of the coordinate axes. The motion of the body is referred to axes fixed in space by means of the Eulerian angles θ, φ, ψ through the well-known equations[1]

$$
\begin{aligned}
\omega_x\,dt &= d\psi \sin\theta \sin\varphi - d\theta \cos\varphi \\
\omega_y\,dt &= d\psi \sin\theta \cos\varphi + d\theta \sin\varphi \\
\omega_z\,dt &= d\varphi - d\psi \cos\theta
\end{aligned}
\qquad (7)
$$

The equations of rotation may now be expressed by means of the Lagrangian formula[1]

$$
\frac{d}{dt}\frac{\partial T}{\partial q'} - \frac{\partial T}{\partial q} = Q \qquad (8)
$$

replacing q and $q' = \dfrac{dq}{dt}$ by θ, φ, ψ and θ', φ', ψ' successively, and Q by the moments of the applied forces. It will suffice here to make the φ-substitution, which will give the equation of rotation with respect to the z-axis. The other equations may be written down by cyclic interchange of symbols.[2]

Observing that f, g, h, and T_1, as defined by (4) and (5) do not contain $\theta, \varphi, \psi, \theta', \varphi', \psi'$, we get from (6) and (7)

$$
\frac{\partial T}{\partial \varphi'} = \frac{\partial T}{\partial \omega_z}\frac{\partial \omega_z}{\partial \varphi'} = C\omega_z + h
$$

and

$$
\begin{aligned}
\frac{\partial T}{\partial \varphi} &= \frac{\partial T}{\partial \omega_x}\frac{\partial \omega_x}{\partial \varphi} + \frac{\partial T}{\partial \omega_y}\frac{\partial \omega_y}{\partial \varphi} \\
&= (A\omega_x + f)\,\omega_y - (B\omega_y + g)\,\omega_x
\end{aligned}
$$

These values in (8) give the third of the following equations, Q being replaced by the usual symbols for the moments of the external forces.

$$
\begin{aligned}
\frac{d\,(A\omega_x+f)}{dt} - (B\omega_y+g)\,\omega_z + (C\omega_z+h)\,\omega_y &= L \\
\frac{d\,(B\omega_y+g)}{dt} - (C\omega_z+h)\,\omega_x + (A\omega_x+f)\,\omega_z &= M \quad (9) \\
\frac{d\,(C\omega_z+h)}{dt} - (A\omega_x+f)\,\omega_y + (B\omega_y+g)\,\omega_x &= N
\end{aligned}
$$

These equations agree in form with those given first by LIOUVILLE (p. 14 of the Journal cited above). They are entirely general, it being understood that the principal (movable) axes of inertia are the coordinate axes. They are readily changed into EULER'S well-known form for the equations of rotation of a rigid body; for in this case we have only to suppose A, B, C, each constant and place

$$
f = g = h = 0
$$

We may simplify equations (9) somewhat without limiting their generality by the following substitutions:

$$
\begin{aligned}
f &= -A\alpha \\
g &= -B\beta \\
h &= -C\gamma
\end{aligned}
\qquad (10)
$$

$$
\begin{aligned}
\omega_1 &= \omega_x - \alpha \\
\omega_2 &= \omega_y - \beta \\
\omega_3 &= \omega_z - \gamma
\end{aligned}
\qquad (11)
$$

---

[1] See, for example, TISSERAND'S *Mécanique Céleste*, Tome II, Chap. XXII.

[1] See especially BERTRAND'S Note VI to Vol. I of the *Mécanique Analytique*.

[2] For details of this process applied to a rigid body, see Chap. XXII, Tome II, of TISSERAND'S *Mécanique Céleste*.

With these values (9) assume the form

$$
(12)\qquad
\begin{aligned}
\frac{d\,(A\omega_1)}{dt} - B\omega_2\,(\omega_3+\gamma) + C\omega_3\,(\omega_2+\beta) &= L\\
\frac{d\,(B\omega_2)}{dt} - C\omega_3\,(\omega_1+\alpha) + A\omega_1\,(\omega_3+\gamma) &= M\\
\frac{d\,(C\omega_3)}{dt} - A\omega_1\,(\omega_2+\beta) + B\omega_2\,(\omega_1+\alpha) &= N
\end{aligned}
$$

3. *Application of the equations to the earth.* In applying the equations of motion to the case presented by terrestrial variations of latitude, we proceed on the assumption that the second members of (9) and (12) are each zero, or that the variations in question are not due to external causes, unless such causes, like heat, produce changes in distribution of the mass.

Placing the second members of (12) equal to zero, and then multiplying them by $A\omega_1$, $B\omega_2$, $C\omega_3$, respectively, the sum of the products gives the following integral:

$$
(13)\qquad (A\omega_1)^2 + (B\omega_2)^2 + (C\omega_3)^2 = G^2 \quad \text{say}
$$

which expresses the principle of the conservation of areas, or, more correctly, the conservation of moment of momentum; G being the constant moment of momentum, or Poinsot's "impulsive couple." Hence, if ξ, η, ζ denote the direction-cosines of the normal to the invariable plane, referred to the moving axes of x, y, z, respectively,

$$
(14)\qquad
\begin{gathered}
\xi = \frac{A\omega_1}{G}, \quad \eta = \frac{B\omega_2}{G}, \quad \zeta = \frac{C\omega_3}{G}\\
\xi^2 + \eta^2 + \zeta^2 = 1
\end{gathered}
$$

With these substitutions (12) may be put in the following form, due to Lord Kelvin:[1]

$$
(15)\qquad
\begin{aligned}
\frac{d\xi}{dt} + \eta\zeta\left(\frac{1}{B} - \frac{1}{C}\right) G - \gamma\eta + \beta\zeta &= 0\\
\frac{d\eta}{dt} + \zeta\xi\left(\frac{1}{C} - \frac{1}{A}\right) G - \alpha\zeta + \gamma\xi &= 0\\
\frac{d\zeta}{dt} + \xi\eta\left(\frac{1}{A} - \frac{1}{B}\right) G - \beta\xi + \alpha\eta &= 0
\end{aligned}
$$

These equations are not independent, since ξ, η, ζ are related as shown by the second of (14).

The A, B, C, α, β, γ which figure in (15) must, in general, be considered as functions of the time. α, β, γ as defined by (4) and (10) appear in the *rôle* of perturbing angular velocities due to changes in form of the rotating body. If definite values could be assigned to these functions, and if equations (15) could be integrated, we might be able to go back through (14), (11), and (7), and define all the circumstances of motion from any assumed epoch. But the causes which give rise to these functions cannot be specified completely at present; and we must try, therefore, to assign them such forms as will include the effects, whatever the causes may be. Fortunately, several circumstances presented by the earth render this task less difficult than it would appear to be. In the first place, the amount of the variation of the latitude of any place is very small, less than 1″, say, to use a round number. Secondly, theory shows that the instantaneous axis of rotation is always very near to the normal to the invariable plane, the angle between these lines being very closely $\frac{(C-A)}{C}$ times the latitude-variation. Thirdly, we are constrained to believe that the principal moments of inertia of the earth and the positions of the principal axes change very slowly; so that for the limited period of precise observational astronomy we may, as a first approximation at any rate, consider these moments and positions invariable. Fourthly, the perturbing angular velocities α, β, γ must be very small in comparison with the instantaneous angular velocity of the earth. These considerations lead to the following simplication of the problem.

From the second of (14) it appears that

$$
\zeta = 1 - \tfrac{1}{2}(\xi^2+\eta^2) + \ldots .
$$

Hence, neglecting terms of the order $\xi(\xi^2+\eta^2)$, $\alpha(\xi^2+\eta^2)$, etc., the first two of equations (15) become

$$
\begin{aligned}
\frac{d\xi}{dt} + \eta\left(\frac{G}{B} - \frac{G}{C} - \gamma\right) + \beta &= 0\\
\frac{d\eta}{dt} - \xi\left(\frac{G}{A} - \frac{G}{C} - \gamma\right) - \alpha &= 0
\end{aligned}
\qquad (16)
$$

If we denote by x_0, y_0, z_0, the coordinates of the point where the instantaneous axis of rotation pierces the northern hemisphere, and by r the radius vector of that point, the direction-cosines of the instantaneous axis will be given by

$$
\begin{aligned}
\frac{x_0}{r} &= \frac{\omega_x}{\omega}\\
\frac{y_0}{r} &= \frac{\omega_y}{\omega}\\
\frac{z_0}{r} &= \frac{\omega_z}{\omega}\\
\omega^2 &= \omega^2_x + \omega^2_y + \omega^2_z
\end{aligned}
\qquad (17)
$$

ω, or the instantaneous angular velocity of the earth, being only slightly greater than ω_z. Recurring to equations (11) and (14), and observing that G is very nearly the same as $C\omega$, we find

$$
\begin{aligned}
\frac{x_0}{r} &= \frac{C}{A}\xi + \frac{\alpha}{\omega}\\
\frac{y_0}{r} &= \frac{C}{B}\eta + \frac{\beta}{\omega}
\end{aligned}
\qquad (18)
$$

Hence, in view of the approximate equality of A, B and C, and of the smallness of the fractions $\frac{\alpha}{\omega}$ and $\frac{\beta}{\omega}$, we may regard ξ and η as the rectangular coordinates (in arc, or radians) of the instantaneous position of the north pole of rotation with respect to the pole of figure as origin. It should be remarked, however, that the work which follows does not require the assumption of near equality of A, B, C, nor the neglect of the ratios of α and β to ω.

---

[1] See Appendix C to Darwin's memoir cited above.

We proceed now to integrate (16) on the assumption that, for the limited interval of time considered, A, B, and C remain sensibly constant. We assume, also, that α and β are functions of the time, the form of which will be specified further on.

With respect to the angular velocity γ a question of some obscurity is presented. It would appear from (10) and (11) that γ must be negligible with respect to

$$\frac{G}{A}, \quad \frac{G}{B}, \quad \text{and} \quad \frac{G}{C}$$

which do not differ much from ω, the resultant angular velocity of the earth; but whether γ is negligible with respect to the differences

$$G\left(\frac{1}{B} - \frac{1}{C}\right) \quad \text{and} \quad G\left(\frac{1}{A} - \frac{1}{C}\right)$$

is not altogether clear. Although we have assumed that the principal axes of inertia are fixed in the earth, it is conceivable that A and B are so nearly equal that the tide entailed by the motion of the axis of rotation about the axis of figure would cause the axes of A and B to revolve with an appreciable angular velocity about the axis of C; and in this case γ in (16) would stand for that angular velocity. If the motion of the axis of rotation about that of figure is sensibly uniform, as Dr. **Chandler's** investigations show, this value of γ will be sensibly constant. We shall assume then, for the present, that γ if variable does not sensibly affect the constancy of the coefficients of ξ and η in (16). A little later on, (in § 5) it will be shown how an appreciable angular velocity for which γ stands may arise through α and β.

Another important question raised by the coefficients of ξ and η in (16) is whether A and B are sensibly equal. For more than a century it has been customary to consider them equal; and it seems probable that they are so, but we shall entertain the hypothesis of inequality in order to show the effect of such inequality on the so-called Eulerian cycle. Supposing A and B unequal, then, let us write for brevity

$$(19) \qquad \begin{aligned} \lambda_1 &= \frac{G}{B} - \frac{G}{C} - \gamma \\ \lambda_2 &= \frac{G}{A} - \frac{G}{C} - \gamma \\ \lambda^2 &= \lambda_1 \lambda_2 \end{aligned}$$

Then, by elimination, equations (16) give

$$(20) \qquad \begin{aligned} \frac{d^2\xi}{dt^2} + \lambda^2\xi + \lambda_1\alpha + \frac{d\beta}{dt} &= 0 \\ \frac{d^2\eta}{dt^2} + \lambda^2\eta + \lambda_2\beta - \frac{d\alpha}{dt} &= 0 \end{aligned}$$

and the complete integrals of these are[1]

$$(21) \qquad \begin{aligned} \xi &= p\cos(\lambda t + P) + \frac{1}{\lambda}\int^t \left(\lambda_1\alpha + \frac{d\beta}{dt}\right)\sin\lambda(\tau - t)\,d\tau \\ \eta &= p\sin(\lambda t + P) + \frac{1}{\lambda}\int^t \left(\lambda_2\beta - \frac{d\alpha}{dt}\right)\sin\lambda(\tau - t)\,d\tau \end{aligned}$$

where p and P are constants (amplitude and phase-angle respectively) and τ is an integration symbol which must be replaced by t after the integration.

The first terms of (21) specify motion of the pole of rotation in a circle with angular velocity λ about the pole of figure. The terms dependent on the τ-integration will be specified in § 6. We must first examine the data which have generally been considered as determining the value of λ.

1. *The angular velocity* λ. As stated above, it has been customary to assume that the moments of inertia A and B of the earth are equal, and hence that λ_1 and λ_2 of (19) are equal. It has also been assumed that this common angular velocity can be determined accurately by means of the ratio of the moments of inertia involved in the expression of precession. The validity of both these assumptions may be fairly questioned, especially since the observed value of λ differs from the computed value by more than 40 per cent of the latter. Let us examine this matter in detail.

Precession furnishes the following ratio:

$$\frac{C - \frac{1}{2}(A + B)}{C} = e$$

where $e = 0.0033$ approximately. From this ratio we readily find

$$\frac{1}{\frac{1}{2}(A+B)} - \frac{1}{C} = \frac{e}{C(1-e)} \qquad (22)$$

This, multiplied by G, which is very nearly equal to $C\omega$, gives the angular velocity of the Eulerian cycle, whose period is found from the numerical value of e to be about 305 sidereal days. It should be observed that the computation of these values of the angular velocity and cycle does not require any assumption with respect to the relative magnitudes of A and B. If, however, $A = B$, this angular velocity makes λ_1 and λ_2 of (19) equal. But let us suppose A and B unequal and inquire what modification will result in the values of λ_1 and λ_2, and hence in λ. The answer is that the value of λ will be less than the angular velocity computed from the precession ratio as above; or, in other words, if A and B are unequal the Eulerian cycle is too short. To prove this, we observe that (22) gives for the functions of A, B, C, in (19)

$$\begin{aligned} \frac{1}{B} - \frac{1}{C} &= \frac{e}{C(1-e)} - \frac{B-A}{2BC(1-e)} \\ \frac{1}{A} - \frac{1}{C} &= \frac{e}{C(1-e)} + \frac{B-A}{2AC(1-e)} \end{aligned}$$

For brevity put

$$\begin{aligned} \lambda_0 &= \frac{Ge}{C(1-e)} \\ l_0 &= \frac{(B-A)G}{2AC(1-e)} = \frac{(B-A)G}{2BC(1-e)} \end{aligned} \qquad (23)$$

the last member of the last equation being permissible by reason of the smallness of $(B-A)$ with respect to A or B. λ_0 is the angular velocity of the Eulerian cycle, or the velocity computed from the precession ratio e. Substituting the values from (23) in (19) there result

---

[1] See, for example, Forsyth's Differential Equations, p. 65.

$$
\begin{aligned}
\lambda_1 &= \lambda_0 - (l_0+\gamma) \\
\lambda_2 &= \lambda_0 + (l_0+\gamma) \qquad (24) \\
\lambda^2 &= \lambda^2_0 - (l_0+\gamma)^2
\end{aligned}
$$

Thus λ is necessarily less than λ_0.

It is important now to inquire how great the difference $(B-A)$ would need to be to account for the observed departure from the Eulerian cycle. For this purpose we have, using the sidereal day as unit of time, the following data:

$$\text{Theoretical value of} \qquad \lambda_0 = \frac{2\pi}{305}$$

$$\text{Observed value of} \qquad \lambda = \frac{2\pi}{428}$$

whence, supposing for the moment that γ is insignificant, we get from (24)

$$l_0^2 = \lambda_0^2 - \lambda^2 = (2\pi)^2 \left\{ \frac{1}{(305)^2} - \frac{1}{(428)^2} \right\}$$

$$\text{Hence} \qquad l_0 = \frac{2\pi}{435}$$

and from the second of (23), since $G = 2\pi C$ very nearly, it follows that

$$B - A = \tfrac{1}{217} A(1-e)$$

Thus, since e is about 0.0033, it follows that $(B-A)$ must be in round numbers $\frac{1}{200}$ part of A or B in order to account for the observed diminution of the Eulerian angular velocity.

The existence of so great a difference as this in the moments A and B appears to be quite impossible. Indeed, the best authorities hold that the differences $(C-A)$ and $(C-B)$ are only about $\frac{1}{1000}$ of A or B, and that the difference $(B-A)$ is only about $\frac{1}{100}$ of $(C-A)$.[1] But the computation of the relative values of the moments A, B, C, requires the assumption of the near equality of A and B, since we have only two directly observable relations of these three quantities. These relations are that furnished by precession, equation (22), and another derived from the moon's motion, giving an equation of the form[2]

$$C - \tfrac{1}{2}(A+B) = \text{constant}.$$

The justification of the assumption of near equality of A and B is found in the fact that the acceleration of gravity as observed by the pendulum does not appear to depend on the longitude of the place of observation. The effect of a difference in A and B on the value of the acceleration of gravity is expressed by

$$g \cdot \tfrac{3}{4} \cdot \frac{B-A}{Mr^2} \cos^2\varphi \cos 2L$$

where g is the equatorial mean value of the acceleration, M the mass and r the radius of the earth, and φ and L are the latitude and longitude respectively of the place of observation. Since A and B are about $\frac{1}{3} Mr^2$ each, a difference, $(B-A)$, as great as $\frac{1}{200}$ of A would produce along the equator a variation of $\frac{1}{300}$ of g from its mean value. The limited data we have from pendulum observations would seem to exclude any such magnitude for the difference $(B-A)$, but those data cannot be regarded as conclusive against an appreciable value of $(B-A)$.

There is another aspect of this question to which attention may be called, namely, that the moments of inertia which figure in the relations furnished by precession and the moon's motion are not the same moments which figure in the expression for the acceleration of gravity at the earth's surface. While it does not appear that the differences of these two sets of moments can be appreciable in affecting the Eulerian cycle, the information we possess is not sufficient to warrant our ignoring this point.

We conclude, then, from the inquiry in this section, first, that any appreciable difference of the moments of inertia A and B makes the angular velocity less than the Eulerian value; secondly, that the information we possess though indicating the near equality of A and B is not decisive. Hence, without rejecting the hypothesis of inequality of A and B as entirely untenable, we proceed to examine another which will account for the observed diminution of the Eulerian angular velocity without serious disturbance to our preconceptions.

5. *Hypothesis of special values of the angular velocities α and β.* Referring to equations (16) and (19), and assuming $\lambda = \lambda_1 = \lambda_2$, (16) become

$$
\begin{aligned}
\frac{d\xi}{dt} + \lambda\eta + \beta &= 0 \\
\frac{d\eta}{dt} - \lambda\xi - \alpha &= 0
\end{aligned}
\qquad (25)
$$

The form of these suggests that λ may undergo effective modification through the perturbing angular velocities α and β. Thus let us assume that

$$
\begin{aligned}
\alpha &= -a\lambda\xi + \alpha' \\
\beta &= -a\lambda\eta + \beta'
\end{aligned}
\qquad (26)
$$

where a is a constant and α' and β' are functions of the time as yet unassigned. Substituting these values in (25) there result

$$
\begin{aligned}
\frac{d\xi}{dt} + \lambda(1-a)\eta + \beta' &= 0 \\
\frac{d\eta}{dt} - \lambda(1-a)\xi - \alpha' &= 0
\end{aligned}
\qquad (27)
$$

Disregarding α' and β' for the moment and writing for brevity

$$\lambda' = \lambda(1-a) \qquad (28)$$

the integrals of (27) are

$$
\begin{aligned}
\xi &= p\cos(\lambda' t+P) \\
\eta &= p\sin(\lambda' t+P)
\end{aligned}
\qquad (29)
$$

p and P being constants.

---

[1] See, for example, the treatises of HELMERT and TISSERAND cited above.

[2] See HELMERT'S *Geodäsie*, II, pp. 466 – 473.

The equations (29), it will be observed are of precisely the same form as the first terms of (21); and we have now to determine what value of the constant a will make λ' agree with the observed angular velocity. We have for the day as unit of time,

$$\text{Observed value of} \qquad \lambda' = \frac{2\pi}{428}$$

$$\text{Eulerian value of} \qquad \lambda = \frac{2\pi}{305}$$

whence by (28)

$$a = \frac{123}{428} = \frac{2}{7}, \text{ nearly.}$$

Thus, if this hypothesis is tenable, the constant a in (26) and (27) should be about $\frac{2}{7}$, and the parts of the angular velocities α and β we are here considering should be of the order $a\lambda\xi$. Since ξ and η are certainly less than the arc of 1″, these angular velocities are of the order

$$\frac{2}{7}\cdot\frac{2\pi}{305}\cdot\frac{1}{206\,265}$$

or, in round numbers,

$$\frac{2\pi}{210\,000\,000}$$

This is equivalent to about $\frac{1}{200}$ of a second of arc per day.

Such a minute angular velocity is of the order we should naturally expect to result from the tides generated by the rotation of the instantaneous axis of the earth about its axis of figure[1].

That the magnitudes of the corresponding displacements of the mobile portions of the earth are not excessive, is shown by the following comparison.

Recurring to (4) and (10) let us compute the angular velocity which must be given to the atmosphere in order to make $f = -A\alpha$ when $\alpha = \frac{1}{200}''$ per day. The moment $A = \frac{1}{3}Mr^2$ nearly, where M is the mass and r the radius of the earth. The mass of the atmosphere is about one-millionth of M, or $M10^{-6}$, say. Its moment of inertia, then, taken relatively to a diameter of the earth will be less than $\frac{2}{3}Mr^2 10^{-6}$. Hence, if ω' denote the angular velocity required,

$$f = \tfrac{2}{3}Mr^2\omega' 10^{-6} = \tfrac{1}{3}Mr^2\alpha$$

whence, if $\alpha = \frac{1}{200}''$ per day, $\omega' = 2500''$ per day, which is equivalent to a linear velocity along the earth's surface of about 41 miles per day. When, therefore, we consider that the mass of the oceans is about two hundred times the mass of the atmosphere, the angular velocities postulated above present nothing surprising.

It might appear that the forms assumed for α and β in (26) are too restricted. It is evident, however, from a glance at (18) that (26) express the parts of α and β which depend on ξ and η in the proper form, since those parts may be figured as arising from changes in the moments A and B. Moreover, we might have assumed

$$\alpha = -a\lambda\xi + \alpha'$$
$$\beta = -b\lambda\eta + \beta'$$

where a and b differ, without any change in the form of (29), as may be seen by reference to (19), (20), and (21).

It appears, then, that in so far as the displacements of the movable parts of the earth entailed by the motion of the instantaneous axis about the axis of figure are proportional to ξ and η, their effect is to decrease the Eulerian angular velocity. The specification of equations (26) applies also to the possible distortion of the earth as a whole, which has been adduced by Professor NEWCOMB to explain the observed elongation of the Eulerian cycle.[1] That some such distortion occurs seems not improbable; but its effect would appear to me small in comparison with that of the mobile oceans and atmosphere. There seems to be no way of evaluating these effects separately, however, and it must therefore suffice to secure their proper symbolic expression,[2] leaving to observation the determination of the constants which are involved in the final formulas for the resultant motion of the instantaneous pole.

However unsatisfactory the evidence adduced in this and the preceding section may be in a quantitative sense, we seem to be forced to the conclusion that the Eulerian cycle as deduced from the the precession ratio is untrustworthy, and that it can no longer be maintained as a dogma of dynamical astronomy. We seem, also, whatever may be the possible complete values of the perturbing angular velocities α and β, obliged to conclude that equations (21) afford a correct statement of the motion in question so far as concerns its general form. The angular velocity λ, as well as the amplitude and phase-angle which enter the first terms of the second members of (21), appear to be derivable by observation only.

We proceed now to complete the expression of the coordinates ξ, η of (21) by evaluating the τ-integrals which depend on the general values of α and β.

6. *Theoretical formulas for the coordinates of the pole of rotation.* It is easily seen that the terms arising from the τ-integration in equations (21) will depend on the forms assigned to α and β. In addition to the case considered in the previous section, three others only seem to present themselves in the actual circumstances of the earth. These are, first, that in which α and β are due to impulsive forces, like those developed by earthquakes, volcanic ex-

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[1] It appears that such a tide has been clearly made out. See a paper by H. G. VAN DE SANDE BAKHUYZEN, *Ueber die Aenderung der Polhöhe*, *Astronomische Nachrichten*, No. 3261.

[1] *Monthly Notices of the Royal Astronomical Society*, March, 1892.

[2] It would appear important that such tidal observations as have been sufficiently extended to afford trustworthy data for the evaluation of the tide corresponding to the motion of the pole, should be carefully discussed; and that observations should be made systematically in the future with a view to disentangling these effects.

plosions, violent storms, etc., which act for short intervals of time and then cease; secondly, that in which α and β are constant, as in the case of secular sedimentation, glaciation, etc.; and, thirdly, that in which α and β are periodic functions of the time, as in meteorological disturbances.

The results I get for the first two of these cases agree with those derived for the first time by DARWIN and KELVIN, and considered in greater detail by HELMERT and TISSERAND in the works cited above. It may therefore suffice here to indicate these results without dwelling on the analytical details.

In the first case, the evaluation of the integrals in (21) shows that immediately after the impulsive disturbances the coordinates assume the forms

$$\begin{aligned} \xi &= (p+p')\cos(\lambda t+P) \\ \eta &= (p+p')\sin(\lambda t+P) \end{aligned} \tag{30}$$

where p' represents the change in amplitude. Thus the motion of the pole of rotation about the pole of figure continues circular with unchanged angular velocity λ, but with a new amplitude.

In the second case, or that in which α and β are assumed constant, the integrals in (21) show that, at a time t after any assumed epoch

$$\begin{aligned} \xi &= -\frac{\alpha}{\lambda}+p_0\cos(\lambda t+P_0)+p_1\cos(\lambda t+P_1) \\ \eta &= -\frac{\beta}{\lambda}+p_0\sin(\lambda t+P_0)+p_1\sin(\lambda t+P_1') \end{aligned} \tag{31}$$

where p_0 and P_0 are the amplitude and phase-angle at the beginning of the time, and

$$\begin{aligned} p_1\cos P_1 &= \frac{\alpha}{\lambda} \\ p_1\sin P_1 &= \frac{\beta}{\lambda} \end{aligned} \tag{32}$$

These show that the pole of rotation follows the pole of figure, and rotates about the latter with the same angular velocity λ as at the beginning of the time, but with a changed amplitude. It should be observed, however, that the ratios in (32) on which this changed amplitude depends, must have been exceedingly small during the relatively brief history of precise observational astronomy. Thus, for example, it is impossible that the axes of B and C can have turned gradually about the axis of A by as much as $1''$ of arc during the past century. This impossible value for α is equivalent to $\frac{1}{36500}''$ per day; and since the value of λ is about $\frac{1296000}{428}''$ per day, the ratio of these velocities which appears in (31) and (32) is in round numbers 10^{-8}, which is equivalent to the arc of $0''.002$ only.

Much more important than the cases just considered is that in which α and β in (21), or α' and β' in (26), are periodic functions, since, as shown by a glance at (21), the new terms arising from such functions may be large by reason of large factors introduced by the integration.

The most comprehensive periodic forms we can assume for α and β are the following:

$$\begin{aligned} \alpha &= \Sigma a_n\cos(n\mu t+\rho_n) \\ \beta &= \Sigma b_n\cos(n\nu t+\sigma_n) \end{aligned} \tag{33}$$

where $n = 1, 2, 3, \ldots \infty$ successively; μ and ν are unassigned constant angular velocities; and a_n, b_n, ρ_n, and σ_n are constants. It might seem that we should assume μ and ν equal, and, further, that the period of each is the year.[1] But there appears to be no reason for such a limitation, except that it is one of several plausible hypotheses we may make with respect to those quantities. In view of the complexity of the causes whose effects are specified by (33), the only safe course in the present state of the inquiry is that which appeals to observation for the discovery of μ and ν as well as for the determination of the constants a_n, b_n, ρ_n, σ_n.

Introducing the values of (33) in (21), assuming

$$\lambda = \lambda_1 = \lambda_2$$

and performing the operations indicated, there result

$$\begin{aligned} \xi &= p\cos(\lambda t+P)-\Sigma\frac{a_n\lambda}{\lambda^2-n^2\mu^2}\cos(n\mu t+\rho_n) \\ &\qquad +\Sigma\frac{nb_n\nu}{\lambda^2-n^2\nu^2}\sin(n\nu t+\sigma_n) \\ \eta &= p\sin(\lambda t+P)-\Sigma\frac{na_n\mu}{\lambda^2-n^2\mu^2}\sin(n\mu t+\rho_n) \\ &\qquad -\Sigma\frac{b_n\lambda}{\lambda^2-n^2\nu^2}\cos(n\nu t+\sigma_n) \end{aligned} \tag{34}$$

In these equations, p and P are constants as already defined, but they arise here from the sum of the first term in (21), and an additional term of the same form coming from the integration. The assumption of equality of λ, λ_1, λ_2, it may be remarked, affects the magnitudes of the constants a_n, b_n only, without changing the form of (34).

Thus, in this case, which appears to be the one with which astronomy is most concerned, the motion of the pole of rotation is defined as the resultant of three distinct types of motion, namely: First, a motion in a circle whose centre is the pole of figure, with sensibly constant angular velocity λ; secondly, the sum of a series of elliptical motions dependent on the angular velocity μ; thirdly, the sum of a series of elliptical motions dependent on the angular velocity ν. Although these series of elliptical terms are infinite, it is practically certain that a small number of terms will suffice to express the observed motions of the pole of rotation.

With regard to the coefficients in the elliptical terms it should be remarked that they may assume quite appreciable magnitudes from otherwise insignificant causes if the angular velocities λ, μ, ν are such as to render $(\lambda^2-n^2\mu^2)$, etc., sufficiently small.[1] The only practicable method, apparently, of determining these coefficients, as well as the amplitude p is that afforded by precise observations of the actual motions of the pole. By this method we virtually get the values of the coordinates of the instantaneous position of the pole, rather than those of the position of the normal to the invariable plane, as may be seen by reference to (18); but it is probable that observation cannot discover the difference between these two positions.

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[1] This restricted case has been considered by HELMERT. See *Astronomische Nachrichten*, No. 3014.

Without inquiring further into the details of the wide variety of causes whose effects are expressed by equations (31), it may be observed that certain of those causes are of such a nature as to lead us to expect some changes both in the amplitude p and in the angular velocity λ of the circular term. Thus, although the effects of impulsive disturbances must be small in individual cases, their aggregates for considerable intervals of time may produce an appreciable change in the amplitude p. Changes may likewise occur in p through departures of α and β from their average values specified by (33). Similarly, the angular velocity λ may undergo an appreciable change through changes in γ or through irregularity of the disturbances considered in § 5.

Finally, we may observe that equations (34) do not exclude the specification of variations which may arise from causes external to the earth, provided such causes find expression in the periodic forms assigned to α and β in (33). For, from the purely inductive point of view we may regard (31) as affording a comprehensive expression for periodic variations in position of the pole whatever may be their causes. This, then, is an additional reason for leaving the angular velocities μ and ν unassigned in our analytical investigation.

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[1] For example, if the periods corresponding to μ and ν are each 12 months (that corresponding to λ being 14 months), the factors of a_1 and b_1 in (34) will be 7.2; that is, the disturbance dependent on these first terms will be magnified sevenfold.

EPHEMERIS OF VARIABLES OF THE *ALGOL*-TYPE.

Greenwich Mean Time.

By PAUL S. YENDELL.

		h
June		
2	*U* Coronae	12
	δ Librae	11
	Z Herculis	18
	U Ophiuchi	18
3	*U* Ophiuchi	14
	Y Cygni	19
4	δ Librae	10
	U Cephei	17
	S Cancri	11
6	*Z* Herculis	17
	Y Cygni	19
7	*U* Ophiuchi	19
8	*U* Ophiuchi	15
9	δ Librae	11
	U Coronae	9
	U Ophiuchi	11
	U Cephei	16
	Y Cygni	19
10	*Z* Herculis	17
11	δ Librae	18
12	*Y* Cygni	19
	U Ophiuchi	19
13	*U* Ophiuchi	16
June		
14	*U* Ophiuchi	12
	U Cephei	16
	Z Herculis	17
15	*Y* Cygni	19
16	δ Librae	10
17	*U* Ophiuchi	20
18	δ Librae	18
	U Ophiuchi	16
	Z Herculis	16
	Y Cygni	19
19	*U* Ophiuchi	12
	U Cephei	16
	U Coronae	18
20	*U* Ophiuchi	8
21	*Y* Cygni	19
22	*Z* Herculis	17
	U Ophiuchi	21
23	δ Librae	10
	U Ophiuchi	17
24	*U* Cephei	15
	U Ophiuchi	13
	Y Cygni	19
25	*U* Ophiuchi	19
June		
25	δ Librae	17
26	*U* Coronae	15
	Z Herculis	17
27	Algol	18
	Y Cygni	19
28	*U* Ophiuchi	18
29	*U* Cephei	15
	U Ophiuchi	14
30	δ Librae	9
	U Ophiuchi	10
	Z Herculis	16
July		
2	δ Librae	17
3	*U* Coronae	13
	U Ophiuchi	19
	Y Cygni	19
4	*U* Cephei	15
	U Ophiuchi	15
	Z Herculis	16
5	*U* Ophiuchi	11
6	*Y* Cygni	19
7	δ Librae	9
July		
8	*U* Ophiuchi	19
	Z Herculis	16
9	δ Librae	17
	U Cephei	14
	U Ophiuchi	15
	Y Cygni	19
10	*U* Coronae	11
	U Ophiuchi	12
11	*U* Ophiuchi	9
12	*Z* Herculis	16
	Y Cygni	19
13	*U* Ophiuchi	20
14	δ Librae	8
	U Cephei	14
	U Ophiuchi	16
15	*U* Ophiuchi	12
	Y Cygni	18
16	δ Librae	16
	Z Herculis	16
17	*U* Coronae	9
18	δ Librae	18
	Y Cygni	18
	U Ophiuchi	21
July		
19	*U* Cephei	14
	U Ophiuchi	17
20	*U* Ophiuchi	13
	Z Herculis	16
	U Coronae	19
21	*U* Ophiuchi	9
	Y Cygni	18
23	δ Librae	16
24	*U* Cephei	13
	Z Herculis	15
	U Ophiuchi	18
	Y Cygni	18
25	*U* Ophiuchi	14
26	*U* Ophiuchi	10
27	*U* Coronae	17
	Y Cygni	18
28	*Z* Herculis	15
29	*U* Ophiuchi	19
	U Ophiuchi	13
30	*U* Cephei	15
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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed May 20.*

THE

ASTRONOMICAL JOURNAL.

No. 346.

VOL. XV. BOSTON, 1895 JUNE 1. NO. 10

ON THE LAW OF RECURRENCE OF ECLIPSES ON THE SAME DAY OF THE TROPICAL YEAR,

BY JOHN N. STOCKWELL.

The ancients discovered two very useful cycles depending on the motions of the sun and moon. The first of these cycles dates from a remote antiquity, and relates to the law of the recurrence of eclipses. It is called the *Saros*, and its period is 223 lunations, or about 18 years and 11 days. The other cycle relates to the recurrence of new or full moons on the same day of the year. It dates from the year 433 B.C., at which time it was proposed by METON at the celebration of the Olympic games, where it was received with acclamation by the people, and adopted by all the cities and colonies of Greece. It is called the *Metonic* or *Lunar cycle*, and consists of 235 lunations, which is very nearly equal to 19 years. The Athenians adopted it for the regulation of their calendar, and had it inscribed in letters of gold on the walls of the temple of MINERVA; and hence the term *Golden Number* which denotes the year of the lunar cycle. We shall now investigate these two cycles, and shall also determine a new cycle, which will be of great use in the discussion of ancient eclipses.

According to observation, the average length of a lunation, or time between two successive new or full moons, is 29.530 587 751 55 mean solar days. We also have

Mean motions of

sun and moon in longitude in a lunation $= 29^\circ.105\,616\,7892$
moon's perigee in a lunation $= 3.288\,733\,8063$
moon's node in a lunation $= -1.564\,872\,5724$

These motions are referred to a fixed equinox, and are therefore not affected by the precession of the equinoxes.

We shall denote the mean longitude of the sun and moon at the time of new moon by nt, and the longitudes of the moon's perigee and ascending node by ω and ☊; so that if we suppose at a given epoch that $nt = \omega =$ ☊ $= 0^\circ$, after 223 lunations we shall have $nt = 10^\circ.552\,544$, $\omega = 13^\circ.387\,639$, and ☊ $= 11^\circ.033\,416$. Therefore, if the sun, moon, perigee and node are together at a given time, after 223 lunations we should have $nt - \omega = -2^\circ.835\,095$, and $nt -$ ☊ $= -0^\circ.480\,872$. They will therefore be in very nearly the same relative positions as at first; and all the eclipse conditions will be repeated very nearly as they took place during the preceding 223 lunations. But since the conjunction of the sun and moon takes place after 223 lunations, $0^\circ.480\,872$ before they arrive at the ascending node, it is evident that the moon's shadow would pass over more southern latitudes until after a certain number of periods, the node at the time of conjunction would have reached the ecliptic limits, and the moon's shadow would just graze the south pole of the earth; after which the eclipses would cease entirely.

It is easy to find the time required for this series of eclipses to take place. For since the node advances before the line of conjunction of the sun and moon by $0^\circ.480\,872$, during each period of 223 lunations, we have only to divide the number of degrees in the solar and lunar ecliptic limits by $0^\circ.480\,872$ in order to find the number of periods, and consequently the time required for that change to take place. Now the solar and lunar ecliptic limits are about $19^\circ.70$ and $13^\circ.35$, respectively. We shall therefore find the time required for the node to advance before the line of conjunction of the sun and moon to the distance of twice these quantities, to be, for the sun 1477 years, and for the moon 1001 years.

If we now continue to follow the node after it has advanced beyond the ecliptic limits, during a period of 5272 years, we shall find that the moon's descending node has advanced so far as to be within the solar ecliptic limits; and a new series of eclipses will commence at the south pole and advance gradually to the northward during each successive period of 223 lunations, until after the lapse of 1477 years, the shadow would pass beyond the earth during another period of more than 5000 years.

Since the mean anomaly of the moon changes by $2^\circ.8351$, during each period of 223 lunations, it follows that the character of eclipses in regard to magnitude in the successive periods will gradually change; and will pass from longest to shortest duration in a period of 1145 years.

We shall now consider the Metonic or Lunar cycle, which has a period of 235 lunations. Now 235 lunations contain 6939.688 1246 mean solar days; and 19 Julian years contain 6939.75 days. Nineteen years therefore exceeds 235 lunations by $0^d.061\,8784$, or by $1^h\,29^m$. This error would amount to one whole day in sixteen Metonic cycles, or 304 years; an error which is of no consequence in this investigation. The changes of the eclipse elements in 235 lunations are as follows:

The change of
date is 19 years, or $\Delta t = 6939^d.688\,121\,6$
mean longitudes of sun and moon, or $\Delta nt = -\ 0^\circ.180\,051\,5$
longitude of moon's perigee, or $\Delta\omega = +52^\circ.852\,144\,5$
longitude of moon's node, or $\Delta\Omega = -\ 7^\circ.715\,054\,5$

These changes are with reference to a fixed equinox; and the motion of the sun's perigee has not been taken into account.

Now if there should be a conjunction of the sun and moon at the node, there would also be a conjunction so near the same node after a period of one lunar cycle that there would be an eclipse. In fact, there would be two eclipses before, and two after the conjunction which took place at the node, making five eclipses on the same day of the year, at intervals of 19 years. We shall now consider the relation of the *Metonic* cycle to the tropical year.

The tropical year is equal to 365.242 213 66 mean solar days; and we must now seek for some relation of commensurability between the length of the tropical year, the length of a lunation, and the time of a complete revolution of the moon's node. As a result of this inquiry, I find that 372 tropical years are very nearly equal to 4601 lunations; and also very nearly equal to 20 revolutions of the node. These intervals expressed in mean solar days are as follows:

	d
372 tropical years are equal to	135870.10348
4601 lunations are equal to	135870.23425
20 revolutions of the node are equal to	135870.700

And the change of eclipse-elements in 4601 lunations are

$$\Delta t = 135870^d.234\,245\,, \quad \Delta nt = -5^\circ.057\,153\,,$$
$$\Delta\omega = +11^\circ.464\,243\ , \text{ and } \Delta\Omega = +0^\circ.021\,294$$

But the precession of the equinoxes in 4601 lunations amounts to $5^\circ.136\,876$; so that the mean longitude of the sun and moon when referred to the movable equinox only changes by $+0^\circ.079\,723$, in a period of 372 years. From this it follows that if an eclipse happened on a given day of the tropical year there would be another eclipse on the same day of the tropical year 372 years afterwards.

Suppose, for example, that a conjunction of the sun and moon took place when the node was, say 19° in advance of the place of conjunction. After a period of 19 years had elapsed a second conjunction would take place, with the node 11°.255 in advance of the place of conjunction; a third conjunction would occur with the node 3°.540 in advance; while a fourth, fifth and sixth conjunction would occur with the node 4°.235, 11°.980 and 19°.725 behind the place of conjunction.

We shall now utilize this theory in the search for a traditional eclipse of the sun which is said to have been observed in China, and which took place on the day of the autumnal equinox, sometime during the twenty-second century B.C. The only trouble that confronts us at the beginning of the investigation is to find an eclipse that took place on the day of the autumnal equinox, at any other date. Fortunately for our purpose, OPPOLZER's great work, "*Canon der Finsternisse*," supplies us with the desired data. The earliest eclipse mentioned in that work, which occurred on the day of the autumnal equinox, was that of the year B.C. 1039 October 3. Three periods, of 372 years each, would amount to 1116 years. And if we subtract this from B.C. 1039 we get B.C. 2155 for the year in which an eclipse would occur on the day of the autumnal equinox, in the twenty-second century B.C. The other dates are found by adding multiples of 19 years to that date; by which we find that new moons took place in the years 2117, 2136, 2155, 2174 and 2193 B.C., on the day of the autumnal equinox in that century. We shall now examine more particularly the circumstances under which those eclipses took place.

If we put T for the date in days of the JULIAN *Period* on which the conjunctions took place, the elements of the several eclipses will be as follows, in which the times and longitudes are corrected for the secular inequalities.

Date B.C.	T	$nt = n't$	ω	Ω	ω'	Precession from A.D. 1850
	d	°	°	°	°	°
2193 Oct. 10	920713.46471	237.0517	243.7615	247.8217	267.468	−55.906
2174 Oct. 11	927653.15536	236.8741	296.5547	240.0433	267.527	−55.645
2155 Oct. 10	934592.84600	236.6965	349.3485	232.2651	267.587	−55.384
2136 Oct. 11	941532.53662	236.5190	42.1424	224.4870	267.646	−55.124
2117 Oct. 10	948472.22723	236.3414	94.9363	216.7090	267.706	−54.864

T denotes mean solar time at Washington, and the longitudes are referred to the mean equinox of 1850 A.D.

For the first date given above, the true time of conjunction was not far from noon in China; but since the moon had not reached the ascending node within about 11°, it follows that the moon's latitude was nearly 1° south, so that no eclipse was possible at that date.

The second eclipse also occurred at a favorable time of day; but the moon's latitude was nearly 30′ south, so that the eclipse was visible only in the southern hemisphere.

The third eclipse occurred at $3^h\,30^m$ p.m. mean time at Washington; and the eclipse was over before sunrise in China. It is evident that at the fifth conjunction, above given, there was no eclipse, because the moon had already passed the ecliptic limits, and no eclipse was possible at that time.

There now remains only the eclipse of B.C. 2136 October 10, to be examined. That eclipse happened when the sun was on the meridian of central China; but the moon's latitude was so far north that it was nowhere central. It was visible, however, as a partial eclipse throughout the whole of the Chinese empire to the northward of Canton; and seems to completely satisfy the tradition concerning it. At the time of the eclipse the sun's longitude was 180° 15′; so that it really occurred on the day of the autumnal equinox. According to the tradition the astronomers Ho and Hi were put to death for having failed to predict it; and we cannot but have a feeling of sympathy for those unfortunate astronomers whose labors were so abruptly brought to a close. The explanation of this oversight of the Chinese astronomers is, however, not difficult to find. For if we examine into the circumstances of the eclipses which were visible in China about that time, we shall find that in the preceding year, on October 21, eleven days after the autumnal equinox, there was a great eclipse visible throughout the whole of China. It was central and annular from Cabul in Afghanistan to the island of Hainan; and was visible as a large eclipse at noon to the whole of China. Now it is a very unusual occurrence for the eclipses of the sun in two consecutive years to be visible at the same place; and I venture to believe that the reason why the astronomers Ho and Hi failed to predict the eclipse of B.C. 2136, October 11, was because they were thrown off their guard by the eclipse of the preceding year. And since the conditions affecting the visibility of eclipses of the sun were not then as well understood as at present, they did not even believe such an event possible.

My attention was first called to the subject of this communication by an article in the November number of the *Observatory* for 1894, which contained an account of Mr. Ginzel's attempt to determine the date of the "*Rig-Veda*" by means of four eclipses which are supposed to be referred to in those sacred poems. One of those eclipses is said to have occurred the *third* day before the autumnal equinox, and was total, or very nearly total, at Lahore in India.

The determination of the date of an eclipse which shall satisfy given conditions, is a very complicated problem; requiring a vast amount of laborious calculations in addition to the analytical skill which renders such a determination possible. As an illustration of this remark, suppose it were required to find the date of an eclipse of at least ten digits in magnitude, which should be visible at Lahore in India; and should also occur within *three days preceding* the autumnal equinox. If we examine the list of 8000 eclipses of the sun which have been calculated and tabulated by Oppolzer, and which covers a period of 3368 years, we shall find that during that long interval of time, not a single eclipse has occurred under the required conditions. It is therefore necessary to push the calculations far into the past in order to find an eclipse that will even approximately correspond with the traditional eclipse. Mr. Ginzel, by calculating the eclipses as far back as the year 2000 B.C., found only one which he was inclined to believe sufficiently similar to be regarded as the true one; and that occurred in the year B.C. 1978, October 5, which was the *sixth day before* the autumnal equinox, instead of the *third*, as the tradition requires. I have, therefore, made some efforts to find an eclipse which was central at Lahore on the third day before the autumnal equinox, at an earlier date than was included in Mr. Ginzel's investigations. By starting with an eclipse which occurred in B.C. 1123, October 1, which is the earliest one given by Oppolzer, that took place the third day before the autumnal equinox, and carrying the dates backward by 372-year intervals, I find that eclipses might be expected to occur three days before the equinox in the years 1495, 1867, 2239, 2611, 2983, 3355, 3727 and 4099 B.C.; and also at a number of 19-year intervals on each side of these dates. But the only eclipse that was visible in India on any of these dates took place B.C. 3784, October 20, or three 19-year intervals before B.C. 3727, which was found by the 372-year intervals. But that eclipse occurred when the sun's longitude was 178° 55′; so that it really took place the *second* day before the equinox, instead of the third. From this circumstance it might be inferred that the cycle of 372 years which I have found, is not correct. But such an inference would be wrong; for the cycle refers only to the mean motions of the sun and moon; and the periodic and secular inequalities which affect the moon's motion during so great an interval may cause an eclipse to take place a day *earlier* than it otherwise would. In this case, however, it took place a day *later* than was expected; but that was due to the fact that the equation of the sun's center at the time of the autumnal equinox had changed by nearly 1° 20′, between the dates B.C. 1123 and B.C. 3784. It would therefore be necessary to start with an eclipse that took place the fourth day before the equinox during the earlier part of Oppolzer's "*Canon*," in order to find one that took place the *third* day before, 3000 years earlier.

It was once remarked by Delambre that if we permit ourselves to deviate from the assigned date of an eclipse to the extent of *four years*, either earlier or later, we are almost certain to find one nearly corresponding in its conditions with that which was given; but we see from the preceding discussion that he must have been slightly mistaken, since we have extended our search through a period of nearly 6000 years, and have failed to find one which completely satisfies the required conditions.

Cleveland, 1895 *April* 10.

NOTES ON VARIABLE STARS.—No. 8.

By HENRY M. PARKHURST.

New Variable in Cetus (857). In the first reduction of the observations of 845 *R Ceti*, in January, the comparison-star DM. −0°365 was included. Upon recording the individual observations in order, I discovered that this star was itself a short-period variable. It was therefore rejected as a comparison-star, and during February and March was observed as a variable. In the following table of Individual Observations, there are three in 1887, derived from the Harvard M.P. observations (Vol. XXIV). My own early photometric observations of this star include five dates, one of which, presumably the first, is unknown. From the observations of the present year I deduced three maxima and four minima, with a period of 18.5 days. From this light-curve and approximate period, I derive the first three maxima given below. Including these observations, I derive the elements: $2395.2 + 18.54\,E$; $(M-m) = 12.1$ days. Several days of the rise are consumed by an intermediate descent of unknown extent and duration.

Results of Observations.

No.	Star	Phase	Observed Date Julian	Observed Date Calendar	E	Corr.	W	Remarks
				1894-5				
8153	*R Lacertae*	Max.	3051	Aug. 10	14	− 3	3	
8230	*S Aquarii*	Min.		Oct.	–	–	–	Invisible for more than three months
8290	*R Pegasi*	Min.	2498	Feb. 3	41	0	1	Elements
"	"	Max.	3019	July 9	42	−30	1	May have been earlier
8373	*S Pegasi*	Min.	3179	Dec. 16	35	0	8	$(M-m) = 143$. Corresponds with 2862 in *A.J.* 314
8512	*R Aquarii*	Min.	3225	Jan. 31	79	0	0	Assumed; but either later or brighter than last year: *A.J.* 314
8597	*V Ceti*	Min.	–	Jan.	22	–		Invisible for more than two months
8600	*R Cassiopeae*	Min.	3252	Feb. 27	35	− 7	3	
103	*T Andromedae*	Max.	3169	Dec. 6	54	+ 3	9	Yendell's elements, *A.J.* 335
107	*T Cassiopeae*	Min.	3151	Nov. 18	20	−13	5	Infrequent observations
434	*S Piscium*	Max.	3097	Sept. 25	26	−47	1	May have been earlier
466	*U Piscium*	Max.	3249	Feb. 24	32	–	–	Elements; probably at least 10 days later
513	*R Piscium*	Max.	3255.0	Mar. 2	30	+ 3	6	Rapid, but regular changes
782	*R Arietis*	Min.	3196	Jan. 2	56	−14	6	
806	o *Ceti*	Max. A	3237	Feb. 12	31	+30	9	Approximately corresponds with *A.J.* 314
"	"	Max. B	3248	Feb. 23	31	+41	9	Brighter, but not so marked
"	"	Max. C	3256.2	Mar. 3	31	+49	9	Still brighter; possibly still another lost in the west
845	*R Ceti*	Min.	3145	Nov. 12	61	0	2	Approximate min. $12^{M}.9$
"	"	Max.	3220.8	Jan. 26	61	+ 6	9	Correction the same as in *A.J.* 314
(857)	– *Ceti*	Max.	0616	Dec. 10	−96	+ 1	2	1887; possibly nine days later
"	"	Max.	2080	Dec. 13	−17	0	1	1891
"	"	Max.	2394	Oct. 22	0	− 1	4	1892
"	"	Max.	3211.5	Jan. 17	44	0	2	Rise not observed
"	"	Min.	3218.5	Jan. 24	45	+ 1	5	Cloudy next day to min.
"	"	Min.	3237.3	Feb. 12	46	+ 1	5	Cloudy at the min.
"	"	Max.	3248.2	Feb. 23	46	0	8	Steep rise and fall for seven successive days
"	"	Min.	3253.3	Feb. 28	47	− 1	4	Rise lost in the clouds
"	"	Max.	3268.6	Mar. 15	47	+ 2	3	Cloudy at max.
"	"	Min.	3272.5	Mar. 19	48	− 1	2	Rise lost in the horizon
893	*U Ceti*	Min.	3173	Dec. 10	16	–	4	Corresponds with $(M-m) = 122$ days
906	*R Trianguli*	Max. A	3216	Jan. 22	6	+ 3	9	The light-curve remarkable
"	"	Max. B	3245.2	Feb. 20	6	+32	9	Neither max. as bright as that in November, 1892
1113	*U Arietis*	Max.	3135.7	Nov. 2	2	−30	9	Much brighter than last year
1222	*R Persei*	Max.	3233	Feb. 8	58	+13	5	Obs. of Feb. 21 apparently too bright; *A.J.* 319

Individual Observations.

8153 *R Lacertae*.
(Continued from 314.)

Julian	Calendar	Mag.
d	1894	
3019	July 9	10.8
3058	Aug. 17	9.7
3062	21	9.65_2
3070	29	9.95_2

8230 *S Aquarii*.
(Continued from 314.)

Julian	Calendar	Mag.
d	1894	
3097	Sept. 25 to	
3208	Jan. 14	12.0]
11 dates.		

8290 *R Pegasi*.

Julian	Calendar	Mag.
d	1893	
2472	Jan. 8	11.7]
2481	17	11.7]
2499	Feb. 4	12.4]
	1894	
3019	July 9	7.85_4

8290 *R Pegasi*.—Cont.

Julian	Calendar	Mag.
d	1894	
3026	July 16	7.99_2
3058	Aug. 17	9.40_2

8373 *S Pegasi*.
(Continued from 314.)

Julian	Calendar	Mag.
	1894	
3079	Sept. 7	10.1

8373 *S Pegasi*.—Cont.

Julian	Calendar	Mag.
d	1894	
3097.5	Sept. 25	11.81_2
3108.6	Oct. 6	12.1
3122.5	20	12.20_2
3134.6	Nov. 1	12.95_2
3149.5	16	13.4

8373 *S Pegasi*.—Cont.

Julian	Calendar	Mag.
d	1894-5	
3152.5	Nov. 19	13.24_2
3177.5	Dec. 14	13.5
3183.5	20	13.3]
3190.5	27	13.5
3206.5	Jan. 12	13.2]
3208.5	14	13.4
3214.5	20	12.9]
3216.5	22	12.8
3218.5	24	12.6
3236.5	Feb. 11	12.2

8512 *R Aquarii*.

(Continued from 314.)

	1894-5	
3122.5	Oct. 20	9.1
3134.6	Nov. 1	9.1
3152.5	19	9.3
3178.5	Dec. 15	10.46_2
3188.5	25	10.1
3190.5	27	10.1
3206.5	Jan. 12	10.3
3213.5	19	10.4
3214.5	20	10.42_2
3217.5	23	10.47_2
3220.5	26	10.7

8597 *V Ceti*.

(Continued from 314.)

	1894-5	
3109.5	Oct. 7	10.9 :
3122.5	20	12.3
3134.6	Nov. 1	12.9
3152.5	19	13.1
3158.6	Nov. 25 to	
3221.5	Jan. 27	13.0]
6 dates.		

8600 *R Cassiopeae*.

(Continued from 314.)

	1895	
3225.5	Jan. 31	10.0
3239.5	Feb. 14	10.3
3246.6	21	10.9
3256.5	Mar. 3	10.70_2

103 *T Andromedae*.

	1894	
3079	Sept. 7	11.0]
3097.6	25	12.4
3103.6	Oct. 1	11.8
3108.6	6	11.63_2
3122.6	20	11.42_2
3135.5	Nov. 2	10.27_2
3147.6	14	9.63_2
3159.5	26	9.15_2

103 *T Androm*.—Cont.

Julian	Calendar	Mag.
d	1894	
3166.5	Dec. 3	8.81_2
3169.5	6	8.83_2
3177.5	14	9.16_2
3180.6	17	8.95_2
3186.5	23	8.93_2
3194.5	31	9.35_2

107 *T Cassiopeae*.

	1894-5	
3109.5	Oct. 7	11.4
3122.5	20	11.1
3135.5	Nov. 2	12.8
3155.5	22	12.62_2
3162.5	29	12.93_2
3166.5	Dec. 3	12.60_2
3181.5	18	12.9
3190.5	27	11.4
3208.5	Jan. 14	10.5

434 *S Piscium*.

	1894	
3097.6	Sept. 25	9.6
3108.6	Oct. 6	10.0
3122.6	20	10.53_2
3134.6	Nov. 1	10.8
3149.5	16	11.5

466 *U Piscium*.

	1895	
3211.5	Jan. 17	12.75_2
3221.5	27	11.5
3223.5	29	11.97_2
3239.5	Feb. 14	11.29_2
3247.5	22	11.15_2
3256.5	Mar. 3	11.11_2
3258.5	5	10.75_2

513 *R Piscium*.

(Continued from 314.)

	1895	
3239.5	Feb. 14	8.92_2
3247.5	22	7.74_2
3256.5	Mar. 3	6.85_2
3258.5	5	7.22_2
3262.5	9	7.92_2

782 *R Arietis*.

	1894-5	
3166.5	Dec. 3	11.6
3182.5	19	13.4
3194.5	31	13.8
3208.5	Jan. 14	13.5
3218.5	24	13.4
3239.5	Feb. 14	11.6

806 *o Ceti*.

(Continued from 314.)

Julian	Calendar	Mag.
d	1894-5	
3180.5	Dec. 17	8.1
3186.5	23	8.81_2
3191.5	31	8.24_2
3198.5	Jan. 4	8.20
3211.5	17	7.07_2
3213.5	19	6.81_2
3214.5	20	5.63_2
3216.5	22	6.81_2
3217.5	23	5.79_2
3218.5	24	6.00_2
3220.5	26	5.63_2
3221.5	27	5.46_2
3223.5	29	4.51_2
3224.5	30	5.64_2
3225.5	31	5.32_2
3229.5	Feb. 4	4.61_2
3235.5	10	4.56_2
3236.5	11	3.87_2
3238.5	13	3.95_2
3239.5	14	4.33_2
3240.5	15	4.43_2
3242.5	17	5.41_2
3243.5	18	5.27
3245.5	20	4.59_2
3247.5	22	3.90_2
3248.5	23	3.67_2
3249.5	24	4.08_2
3250.5	25	4.42_2
3251.5	26	4.37_2
3256.5	Mar. 3	3.51_2
3258.5	5	3.93_2
3259.5	6	4.69_2
3262.5	9	3.86_2
3263.5	10	3.92_2
3267.5	14	4.32_2

845 *R Ceti*.

(Continued from 314.)

	1894-5	
3097	Sept. 25	10.6
3122.6	Oct. 20	12.4 :
3134.6	Nov. 1	12.5]
3158.6	25	12.5]
3180.5	Dec. 17	11.7
3186.5	23	11.13_2
3211.5	Jan. 17	8.29_2
3213.5	19	8.49_2
3214.5	20	8.00_2
3216.5	22	7.84_2
3217.5	23	7.69_2
3218.5	24	7.64_2
3220.5	26	7.00_2

845 *R Ceti*.—Cont.

Julian	Calendar	Mag.
d	1895	
3221.5	Jan. 27	7.41_2
3223.5	29	7.41_2
3224.5	30	7.41_2
3229.5	Feb. 4	7.98_2

(857) — *Ceti*.

	1887	
0612	Dec. 6	8.61_2M
0618	12	8.41_2M
0619	13	8.61_2M
	1891-2	
2—	?	8.55
2076	Dec. 9	8.34_2
2373	Oct. 1	8.71
2396	24	8.15_2
2398	26	8.73
	1895	
3211.5	Jan. 17	7.92
3213.5	19	8.29
3214.5	20	8.39
3216.5	22	8.62
3217.5	23	8.90
3218.5	24	8.74
3220.5	26	8.83
3221.5	27	8.42
3223.5	29	8.39
3224.5	30	8.42
3235.5	Feb. 10	8.48_2
3236.5	11	8.86_2
3238.5	13	8.88_2
3239.5	14	8.24_2
3240.5	15	8.34_2
3241.5	16	8.45_2
3242.5	17	8.73_2
3245.5	20	8.53_2
3246.6	21	8.39_2
3247.5	22	8.14_2
3248.5	23	8.08_2
3249.5	24	8.24_2
3250.5	25	8.52_2
3251.5	26	9.06_2
3252.5	27	8.7 :
3256.5	Mar. 3	8.34_2
3258.5	5	8.45_2
3259.5	6	8.58_2
3262.5	9	8.62_2
3263.5	10	8.51_2
3267.5	14	8.25_2
3269.5	16	8.21_2
3270.5	17	8.72_2
3271.5	18	8.80_2
3272.5	19	8.99_2

893 *U Ceti*.

Julian	Calendar	Mag.
d	1894	
3135.5	Nov. 2	10.6
3152.5	19	11.1
3153.5	20	11.62_2
3158.6	25	11.8
3162.5	29	12.49_2
3181.5	Dec. 18	12.0]
3188.6	25	11.86_2

906 *R Trianguli*.

(Continued from 314.)

	1894-5	
3194.5	Dec. 31	9.0
3211.5	Jan. 17	8.13_2
3213.5	19	6.91_2
3214.5	20	6.75_2
3216.5	22	7.21_2
3217.5	23	6.64_2
3218.5	24	7.57_2
3220.5	26	7.21_2
3224.5	30	6.77_2
3236.5	Feb. 11	6.38_2
3238.5	13	6.53_2
3240.5	15	6.40_2
3246.6	21	6.27_2
3249.5	24	6.15_2
3256.5	Mar. 3	6.89_2
3262.5	9	6.93_2
3269.5	16	7.16_2

1113 *U Arietis*.

(Continued from 314)

	1894	
3097.6	Sept. 25	9.5
3101.6	29	9.12_2
3113.6	Oct. 11	7.45_2
3122.6	20	7.91_2
3124.6	22	7.32
3134.6	Nov. 1	7.33_2
3135.5	2	7.26_2
3136.6	3	7.21_2
3147.6	14	7.74_2
3153.5	20	7.42_2

1222 *R Persei*.

(Continued from 319.)

	1895	
3211.5	Jan. 17	9.58_2
3214.5	20	9.56_2
3225.5	31	8.99_2
3238.5	Feb. 13	9.35_2
3246.6	21	9.09_2
3258.5	Mar. 5	9.71_2

COMPARISON-STARS.

103 *T Andromedae*.

F	+26°40	8.51	6
I	+25°37	7.98	3
J	+26°42	8.76	8
R	+26°37	9.26	9

103 *T Androm*.—Cont.

1*Z*	+26°48	10.55	7
a	2*n*2*f* 1*Z*	10.66	5
k	1*n*5*f* *V*	12.55	2

893 *U Ceti*.

N	−13°481	8.50	1
1*R*	−13°483	8.46	1
X	−13°474	10.22	2
Y	−13°476	10.64	1

893 *U Ceti*.—Cont.

1*Y*	−13°484	10.70	1
Z	−13°478	11.06	4
e	7*f* *V*	11.49	4
g	5*f* *e*	11.76	4

OBSERVATIONS OF SUSPECTED VARIABLES, 1893–95,

By PAUL S. YENDELL.

(5) — *Ceti.*

Since the notice of this star, published in No. 321 of this Journal, I have observed it four times, as follows:

	M
1894 Oct. 22	8.8
28	8.8
Nov. 19	8.9
Dec. 17	9.0

These observations afford no evidence of variability.

(780) — *Persei.*

From 1894 Jan. 7 to April 25, and Sept. 21 to 1895 Jan. 27, I observed this star twenty-six times. The estimates cover a range of six and a half steps, the greatest deviation from the mean being 4 steps, and the average 1.4 steps. In view of the star's decided color, I am strongly of the opinion that its light has been practically constant during the year 1894.

DM. 59°594.

R.A. = $2^h\ 56^m\ 11^s.2$ Decl. = +59° 55′.4 (1855)

This is No. 849 of Espin's "Stars with Remarkable Spectra" (*Astr. Nachr.*, 3232). Espin gives the magnitude as 8.6, and notes "Var?" I have observations as follows:

	M
1894 Nov. 2	9.3
Dec. 25	9.6
1895 Jan. 17	9.4
27	9.4
Feb. 16	9.3
Mar. 5	9.2

No evidence of variability.

(1279) — *Camelopardalis.*

My observations from 1894 Nov. 3 to 1895 April 21 seem to settle the doubt regarding this star, in favor of the reality of its variation.

As deduced by the same scale applied in my notice on this star (*A.J.* 321), the observed magnitudes are

	M
1894 Nov. 3	7.97
Dec. 19	8.02
1895 Jan. 27	7.80
Feb. 16	7.68
Mar. 5	7.63
Apr. 21	8.45

Taken in connection with my observations of March and April 1894, these observations show too great a change to be imputed to the influence of the star's color, and I feel fairly certain that the observed variation is real.

(1801) — *Camelopardalis.*

Between 1894 Nov. 2 and 1895 March 21, I have observed this star nine times, as follows:

	M
1894 Nov. 2	8.8
Dec. 17	8.6
20	8.9
22	8.6
1895 Jan. 17	8.7
27	8.9
Feb. 16	8.7
Mar. 9	8.7
21	8.6

These observations afford no confirmation of the star's variability.

(5076) — *Bootis.*

Since the observations published in No. 321 of this Journal, I have observed this star six times, as follows:

	M
1894 June 1	9.1
20	9.2
25	9.3
July 26	9.4
Aug. 5	9.4
1895 Mar. 18	9.0

Although the observations made during the summer of 1894 show a slight apparent decrease, the deviations from the mean light observed since 1893 Aug. 22 afford no confirmation of the star's variability.

(6749) — *Scuti.*

My observations of this star, from 1894 June 23 to Sept. 23, five in number, indicate that the star was constant at $7^M.1$ during the time covered by these observations.

DM. 21°3909.

R.A. = $19^h\ 41^m\ 1^s.9$ Decl. = +21° 25′.1 (1855)

This is No. 887 of Espin's list, above referred to. He notes it as "Var?"

My observations from 1894 July 3 to Nov. 2 do not support the assumption of variability; they are

	M
1894 July 3	7.9
Aug. 26	7.9
Sept. 23	7.9
Nov. 2	8.0

DM. 25°4126.

R.A. = $20^h\ 3^m\ 59^s.3$ Decl. = +25° 51′.8 (1855)

This is No. 895 of Espin's list above quoted, and noted "Var?" I have observations as follows:

	M
1894 July 3	9.4
Sept. 23	9.2
Nov. 2	8.9
Dec. 17	8.8

The evidence seems to favor variability, but is not decisive.

(7238) — *Cygni.*

Since the observations of this star published in this Journal, No. 321, I have six observations, as follows:

	M
1893 Oct. 17	9.2
25	8.6 (full moon)
Dec. 28	9.2
1894 May 9	9.1
June 13	8.6

No certain evidence of variability.

(7279) — *Cygni.*

Five observations, from 1894 July 3 to Dec. 19, are not decisive; they are

	M
1894 July 3	9.3
Sept. 23	9.2
Nov. 2	9.0
Dec. 17	8.8
19	8.8

(8106) — *Pegasi.*

I looked for this star three times in 1893, and four times in 1894, and have only once thought I saw anything in its place. The observations are

	M
1893 Sept. 6	<10.0
Oct. 5	<10.0
31	<11.0
1894 Sept. 6	<10.0
23	seen, 12^M ±
Oct. 22	<11.0
Dec. 17	<11.0

DM. 59°594.

R.A. = $2^h\ 56^m\ 11^s.2$ Decl. = +59° 55′.4 (1855)

This is No. 849 of Espin's list of stars with remarkable spectra, above quoted. Espin notes spectrum Type III, "Var?"

Seven observations, from 1894 Nov. 2 to 1895 April 15, show an average departure of only $0^M.07$ from a mean observed magnitude of $9^M.39$, and give no evidence of variability in the star. Its DM. magnitude is $9^M.5$. Espin's estimate $8^M.6$.

DM. 17°1973.

R.A. = $8^h\ 47^m\ 12^s.9$ Decl. = +17° 46′.9 (1855)

This is No. 1303 of the Potsdam Photometric Catalogue, and specially designated in the notes as suspicious. I have seven observations, as follows:

	M
1895 Jan. 27	7.25
Feb. 11	7.75
13	7.9
20	7.9
22	7.3:
Mar. 5	7.4
16	7.35
28	7.85
Apr. 21	6.8

The star's color is given by M. & K. as R. My two observations make it $6^M.7$ on Chandler's scale of color. In view of this circumstance, and the fact that between the observation of March 28 and that of April 21 the hour-angle under which the star was observed changed from East to West, I do not consider its variability certainly confirmed by these observations.

(5626) — *Librae.*

I have three observations of this star in 1893, three in 1894, and one in 1895. These show an average departure of 0.16 from a mean magnitude of 7.5. The star is sensibly white. Probably constant.

DM. 50°2251.

R.A. = $16^h\ 0^m\ 10^s.7$ Decl. = +50° 54′ (1855)

Espin announces the variability of this star in *Wolsingham Circular*, No. 39.

I observed it on 1894 Sept. 23, and found it $8^M.7$, being $0^M.1$ brighter than DM. 50°2250. On observing it again on 1895 April 23, it was found at least six steps fainter than the same star, and two steps fainter than DM. 51°2053, 9.4, and its magnitude was estimated as $9^M.5$.

Considering the position of the first-named comparison-star, about 3′.5 preceding the suspected star, the relative change appears to me to admit of no doubt, and I consider the star's variability as certain, although its color, from one observation, is about 6.3 of Chandler's scale of redness.

R.A = $17^h\ 54^m.3$ Decl. = +58° 14′ (1900)

Espin (*Wols. Cir.* No. 41) finds an 8 magnitude star (not in DM.) in the above position; spectrum of Type IV, and very red. I have observations as follows:

	M
1894 Dec. 13	8.6
15	8.7
1895 Jan. 2	8.6
Apr. 23	9.5

These observations, while not quite decisive, appear to favor the star's variability.

DM. 14°3755.

R.A. = $18^h\ 56^m\ 0^s$ Decl. = +14° 21′.7 (1855)

My attention was called to this star in September, 1894, by Dr. Chandler, in a private letter. I have observations as follows:

	M
1894 Oct. 1	7.7
5	7.3:
6	7.3
7	7.1
11	7.1
18	7.1
19	7.1
22	7.1
27	7.0
Nov. 2	6.9
16	6.8
Dec. 4	7.0
1895 Apr. 23	7.7

The star is sensibly white, and its variation appears to me certain.

Dorchester, 1895 *April* 26.

ON THE LOGICAL NECESSITY THAT ATTRACTION OF GRAVITATION, IF IT DEPENDS ON THE DISTANCE, *MUST* BE AS THE INVERSE SQUARE,*

By CHAS. H. KUMMELL, U.S. Coast and Geodetic Survey, Washington, D.C.

In the important book, recently published by Prof. Simon Newcomb, on the Fundamental Constants of Astronomy, on page 118, Prof. Hall's hypothesis of a modification of the law of attraction is given, whose purpose is to account for the secular motion of the line of apsides of *Mercury*, and which consists in supposing that in the expression

$$\text{force} = \frac{mm'}{r^n}$$

the exponent n is not exactly 2 but $2+\delta$, δ being a very small fraction, and which Prof. Newcomb gives to be 0.000 000 1574. The original article in which Prof. Hall proposes this modification, appeared in the *Astronomical Journal* of June 2, 1894, and has found already a critic in Mr. H. Seeliger, in a recent number of the *Astronomische Nachrichten*. This author, after giving a modification of the Newtonian law of his own, mentions Hall's hypothesis as insufficient because it would involve corresponding movements of the perihelia of the other planets and the moon, far exceeding facts. Thus he objects to Hall's hypothesis on purely arithmetical grounds. But there is a logical objection to it, which makes it inadmissible, even if it would remove all anomalies.

The well-known analytical expression for any force,

$$\text{force} = m\frac{dv}{dt} = m\frac{d^2s}{dt^2} = \text{mass} \times \text{acceleration}$$

implies that a force is proportional to the mass that causes it, and to the change of velocity or acceleration it imparts to a body. Because $m = \delta V = \text{density} \times \text{volume}$, it follows that mass has three dimensions, and since further acceleration is distance, it follows that the analytical expression of any force has four dimensions. If this is equated to any special kind of force for the purpose of studying the circumstances of the motion produced by it, the expression for this must likewise have four dimensions. The well-known expression for the force of gravity

$$\frac{mm'}{r_2} = \text{attracting mass} \times \text{attracted mass}$$

square of distance has indeed four dimensions, and the expressions

$$m\frac{dv}{dt} \text{ and } \frac{mm'}{r^2}$$

are, therefore, capable of perfect equality. If we write for the exponent of r, $2+\delta$ instead of 2, we change the dimensions of the latter to $4-\delta$ dimensions. Of this it is impossible to form any conception, and is therefore inadmissible.

Suppose we know only that attraction of gravitation must be proportional to the masses m, m' which attract each other, and that it depends in some way on the distance between them, then we can put

$$\text{attraction of gravitation} = mm'f(r)$$

The unknown function $f(r)$ must be, however, of -2 dimensions, because the product mm' has 6 dimensions. This leads then to the expression[1]

$$\frac{mm'}{kr^2}$$

where k is an absolute number, independent of mass and distance, and is taken as unity in the usual form of the law. It is, however, evident that this indeterminate quantity k would be of no use for explaining the anomalous motion of *Mercury*.

This mode of reasoning thus conducts inevitably to the well-known form for the attraction of gravitation, yet in no wise it claims to be a metaphysical explanation of it, and I doubt that the human mind will ever discover one that helps over the well-known scholastic maxim that a body cannot act where it is not.

Mr. Seeliger's proposed modification of the Newtonian law is of the form,

$$\text{force of gravitation} = \frac{mm'}{r^2}e^{-\lambda r}$$

If r = distance, λ must be the reciprocal of some linear quantity, in order that the exponent λr may be an absolute number. It is difficult, if not impossible, to see of what linear quantity λ could be the reciprocal. I content myself in having thus given a useful criterion for a correct form for any modification of the Newtonian law; it appears to me, however, as a most plausible theory, to suppose that the anomalous motion of *Mercury* may be due to a resisting medium.[2]

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[1] If we assume kr^n, then, because this must have -2 dimensions, it follows that k must have $-n-2$ dimensions; but whence does k derive its dimensions, if it is independent of mass and distance?

[2] Prof. Hall, however, states that a resisting medium could not account for the anomaly in the motion of *Mercury*, because it is no loss, but a gain of motion that is observed.

* Read before the Philosophical Society of Washington, 1895 March 30. Printed at the author's request.

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Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed May 29.*

THE

ASTRONOMICAL JOURNAL.

No. 347.

VOL. XV. BOSTON, 1895 JUNE 19. NO. 11

REVISED SUPPLEMENT TO SECOND CATALOGUE OF VARIABLE STARS,

By S. C. CHANDLER.

This Revised Supplement to the Second Catalogue (*A.J.* 300) includes all the stars given in Table I of the Supplement (*A.J.* 319), together with the additions necessary to bring our knowledge up to date. Thus the Second Catalogue and the present Revised Supplement furnish together a complete list of known variables, comprising in all 344 stars.

The contents of the various columns here given conform strictly to the explanations in the preface of the Second Catalogue; with the sole exception of the last column of the right-hand page, where, for convenience, the data of "Basis of Elements" are temporarily supplanted by the facts relative to discovery and confirmation.

In the construction of this Supplement an important question arose, whose settlement it did not seem expedient longer to postpone; and a policy has been adopted with regard thereto, after consultation with various astronomers familiar with the subject, which I trust will commend itself to astronomers generally, as the best that can be pursued under the peculiar circumstances. This relates to the large portion of the southern sky inaccessible to northern observers. Numerous announcements of variables in this region have been made on the authority of the examination at the Harvard College Observatory of photographs made at its Boyden station in Arequipa. Experience in many of these cases, where there was independent means of scrutiny, has given abundant reasons for distrust of their accuracy, more especially in the matter of positions and identifications. It has been earnestly hoped that some observer in the southern hemisphere would take up comprehensively the observation of these objects, not only for independent confirmation of variability, but also for determining their positions with suitable accuracy, so that the nomenclature could be certainly settled upon. This hope has not been realized. Meanwhile the want of a definitive notation is pressing. I have therefore decided to rely on the assurances which Prof. Pickering has given, and reiterated in various places, since the Supplement in *A.J.* 319 was issued, that he has in every instance confirmed the announcements made by Mrs. Fleming, by independent examination. It is assumed that his confirmation necessarily includes all that the word implies, namely, right identification and correctness of position, as well as the fact of variability. I have therefore entered all these objects (with a few exceptions where we need more definite information) in this Supplement, and have assigned their letters. This is done because any changes and corrections which may hereafter be necessary can hardly produce so much confusion as the policy of allowing the nomenclature to fall still further into arrears. Wherever, therefore, in the last column of this Supplement, the initials H.C.O., with the date, alone appear, it signifies that the Observatory in question is the sole authority. In all cases where that institution has given conflicting positions, the one last published is used. For 2080 *R Columbae* I have substituted the place given by Dr. Hartwig, who has identified the star with Cord. DM. −29°2538, which precedes by 32 sec., and is 6′ north of that given by Mrs. Fleming, and confirmed by Prof. Pickering. Unless there are two variables here, about 10′ apart, which is of course possible, it seems more prudent to rely on the known critical accuracy of Dr. Hartwig, who appears to have investigated this case. We thus have another illustration of the caution which observers have to exercise in dealing with many of the current announcements of variables, which seem to indicate, not the place of the desired star, but rather a region of the sky where it may be hunted for, having a diameter perhaps half that of the moon. In view of the failure of the Harvard College Observatory to give positions of the requisite accuracy, it is hoped that some southern observer may take this matter under especial charge.

In further pursuance of the policy of bringing up arrears in the notation for the southern sky, I have felt justified in including, with confidence, the short-period variables of Roberts, since he has determined their elements apparently with considerable precision.

List of New Variables, Supplementary to the Catalogue

No.	Star	1900.0		1900 Annual Variation		1855.0		Redness	Magnitude	
		R.A.	Decl.			R.A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
62	S Sculptoris	0 10 19	−32 36.1	+ 3.04	+0.33	0 8 2	—32 51.1	–	6.5	10.0
103	T Andromedae	17 10	+26 26.4	3.12	0.33	14 50	+26 11.4	–	8.2	13?
110	S Tucanae	18 24	−62 14.	2.87	0.33	16 14	—62 29.	–	8.7	<11.6
294	W Cassiopeae	0 48 59	+58 0.9	3.53	0.32	0 46 21	+57 46.5	–	8.4	11.5
691	W Persei	1 55 6	+56 15.	1.03	0.29	1 52 6	+56 2.	–	9.3	<15
980	V Persei	2 43 15	+56 31.1	4.40	0.25	2 39 58	+56 22.6	5.0*	7.9	9.5
1018	R Horologii	2 49 12	−50 21.	1.98	0.25	2 48 13	—50 32.	–	6.2	9.7
1279	U Camelopardalis	3 33 12	+62 19.4	5.12	0.20	3 29 23	+62 10.4	–	7.3	8.8
1662	R Caeli	4 37 4	—38 26.	2.08	0.12	4 35 30	—38 31.	–	7.5	10.5
1701	R Pictoris	4 43 29	−49 25.6	1.60	0.11	42 17	—49 30.6	–	8.1	9.5
1803	T Leporis	5 0 35	−22 2.4	2.55	0.09	58 40	—22 6.3	–	8.2	10.9
1805	V Orionis	0 47	+ 3 58.0	3.16	0.09	4 58 25	+ 3 54.0	4.2*	8.4	12.0<
1850	S Pictoris	8 18	−48 37.7	1.59	0.07	5 7 6	—48 41.1	–	8.6	<13.3
2080	R Columbae	46 40	−29 13.2	+ 2.32	+0.02	5 44 55	—29 14.1	–	7.9	11.4<
2141	R Octantis	5 56 48	−86 26.0	−18.37	0.00	6 10 33	—86 25.7	–	7.4	<11.3
2170	S Leporis	6 1 38	−24 11.2	+ 2.47	0.00	5 59 47	—24 11.1	–	6.7	7.5
3040	V Carinae	8 26 41	−59 47.3	1.24	−0.20	8 25 46	—59 38.3	–	7.2	8.0
3055	X Carinae	29 7	−58 53.2	1.31	0.20	28 8	—58 44.1	–	7.8	8.6
3087	T Velorum	8 31 26	−47 0.7	1.95	0.21	8 32 58	—46 51.3	–	7.5	8.5
3355	W Carinae	9 19 15	−55 32.0	1.82	0.26	9 17 53	—55 20.5	–	7.5	8.5
3416	S Velorum	29 27	−44 45.9	2.26	0.26	27 45	—44 34.1	–	7.8	9.3
3425	X Hydrae	30 44	−14 14.7	2.87	0.27	9 28 35	—14 2.8	–	9.2	<11
3569	RR Carinae	9 54 50	—58 23.0	1.94	0.28	9 53 23	—58 10.2	–	8.2	9.6
3662	Z Carinae	10 10 24	−58 21.	2.07	0.30	10 8 51	—58 8.	–	9.4	12.1
3767	Y Carinae	29 25	−57 59.0	2.25	0.31	27 44	—57 45.1	–	7.8	8.6
3911	U Carinae	10 53 44	−59 11.8	2.43	0.32	10 51 54	—58 57.4	–	6.7	8.5
4364	S Muscae	12 7 24	−69 35.7	3.19	0.33	12 5 1	—69 20.7	–	6.5	7.3
4429	R Crucis	18 8	−61 4.5	3.26	0.33	15 42	—60 49.5	–	6.8	8.0
4435	S Centauri	19 12	−48 53.2	3.20	0.33	16 48	—48 38.2	–	6	?
4488	U Centauri	28 0	−54 6.	3.30	0.33	25 32	—53 51.	–	9.2	11.3
4611	S Crucis	12 48 27	−57 53.3	3.52	0.33	12 45 49	—57 38.5	–	6.6	7.8
4896	T Centauri	13 36 2	−33 5.5	3.43	0.31	13 33 28	—32 51.7	–	6.9	9.1
5144	Y Bootis	14 17 22	+20 15.8	2.79	0.28	14 15 16	+20 28.2	–	8.0	8.6
5174	RS Virginis	22 16	+ 5 7.6	3.00	0.27	20 1	+ 5 19.9	–	8.2	12?
5321	S Lupi	14 46 42	−46 12.	4.00	0.25	14 43 42	—46 1.	–	9.7	<12
5511	RS Librae	15 18 30	−22 34.	3.50	0.22	15 15 53	—22 24.	–	8.4	<11
5533	R Normae	22 11	−50 13.9	4.31	0.21	18 57	—50 4.4	–	7	–
5562	—Apodis	15 27 0	−71 32.	6.22	0.21	15 22 22	—71 23.	–	–	–
5750	U Triang. Austr.	15 58 25	−62 38.3	5.30	0.17	15 54 27	—62 30.6	–	7.7	8.7
5768	RR Herculis	16 1 28	+50 46.3	1.65	0.17	16 0 11	+50 54.2	–	8.7	9.5
5823	S Normae	16 10 35	—57 39.2	4.95	0.15	16 6 52	—57 32.1	–	6.5	7.4
5949	R Arae	31 26	−56 47.6	4.96	0.13	27 43	—56 41.8	–	6.9	8.0
6050	RS Scorpii	48 22	−44 56.3	4.34	0.10	45 7	—44 51.6	–	7.0	11.4
6062	RR Scorpii	50 15	−30 25.3	3.82	0.10	47 23	—30 20.7	–	7.3–7.7	11.6
6101	RT Scorpii	16 56 48	−36 40.	4.03	0.09	16 53 47	—36 36.	–	9.2	12.9<
6207	Z Ophiuchi	17 14 28	+ 1 37.3	3.04	0.07	17 12 12	+ 1 40.3	3.0	8.2	12.5
6275	S Octantis	25 54	−86 46.	26.41	0.04	6 17	—86 43.	–	8.2	<11.7
6331	RU Scorpii	35 6	−43 42.	4.34	0.04	31 51	—43 40.	–	9.3	12.7
6442	Z Herculis	53 36	+15 8.8	2.71	0.01	51 34	+15 9.3	–	7.1	8.0?
6446	T Draconis	17 54 18	+58 14.	+ 0.90	−0.01	17 53 38	+58 14.	–	8.2	9.8

IN No. 300 OF THE ASTRONOMICAL JOURNAL.

No.	$M-m$	Elements of Maximum, Greenwich M.T.				By whom	
		Epoch (Cal.)	Julian	Period	Remarks	Discovered ;	Confirmed
	d		d	d			
62	–	1846 Sept. 22	=239 5562	+366 E	Pickering's elements	H.C.O., 1894 ;	Hartwig
103	–	1855 Sept. 10	239 8837	+265.35 E	Yendell's elements	Anderson, 1893 ;	Hartwig
110	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1895 ;	
294	–	. . . . .	. . . .	. . . .	. . . .	Espin, 1888 ;	J. A. Parkhurst
691	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1890 ;	
980	–	1893 Dec. 29	241 2827	+358 E?	Hartwig's elements	Espin, 1893 ;	Hartwig. Yendell
1018	–	1889 Aug. 30	241 1245	+371 E?	. . . .	H.C.O., 1892 ;	Roberts
1279	–	. . . . .	. . . .	. . . .	. . . .	Birmingham, 1871 ;	H.C.O., Hartwig
1662	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1890 ;	Roberts
1701	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1895 ;	
1803	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1895 ;	
1805	–	1891 Feb. 14	241 1778	+266 E?	. . . .	Boss, 1887 ;	Yendell
1850	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1895 ;	
2080	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1893 ;	Hartwig
2141	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1892 ;	
2170	–	. . . . .	. . . .	. . . .	Irregularly periodic	Sawyer, 1891 ;	Yendell
3040	3.0	. . . . .	. . . .	6.66	Roberts's period	Roberts, 1892 ;	
3055	2.4	1893 Feb. 22	241 2517.3	+ 6.52 E	Roberts's elements	Roberts, 1892 ;	
3087	1.8	. . . . .	. . . .	4.6	Roberts's period	Roberts, 1892 ;	
3355	0.9	. . . . .	. . . .	4.38	Roberts's period	Roberts, 1892 ;	
3416	–	MIN. 1894 May $1^d\ 8^h\ 22^m.5$		$+5^d\ 22^h\ 23^m.4$ E	*Algol*-type, Roberts's el.	Woods, 1894 ;	Roberts
3425	–	1892 Mar. 22	241 2180	+296 E	Paul's elements	Skinner, 1894 ;	H. M. Parkhurst
3569	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1895 ;	
3662	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1895 ;	
3767	0.92	1894 Feb. 9	241 2869.2	+ 3.637 E	Roberts's elements	Roberts, 1893 ;	
3911	6.0	1892 Feb. 1	241 2130	+ 38.6 E	Roberts's elements	Roberts, 1891 ;	
4364	3.5	1892 Jan. 3	241 2101.6	+ 9.66 E	Roberts's elements	Roberts, 1891 ;	
4429	1.4	1891 Dec. 25	241 2092.0	+ 5.827 E	Roberts's elements	Roberts, 1891 ;	
4435	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1889 ;	
4488	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1895 ;	
4611	1.5	1892 Jan. 2	241 2100.4	+ 4.692 E	Roberts's elements	Roberts, 1891 ;	
4896	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1894 ;	
5144	–	. . . . .	. . . .	2.60	*Algol*-type?	H. M. Parkhurst, 1894 ;	Yendell
5174	–	1890 May 22	241 1510	+360 E	. . . .	H.C.O., 1892 ;	Hartwig
5321	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1894 ;	
5511	–	1889 July 9	241 1193	+222 E	. . . .	H.C.O., 1892 ;	Chandler
5533	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1893 ;	Campbell
5562	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1894 ;	not yet confirmed
5750	0.76	1894 Feb. 7	241 2867.7	+ 2.546 E	Roberts's elements	Roberts, 1893 ;	
5768	–	. . . . .	. . . .	. . . .	. . . .	Espin, 1894 ;	Yendell
5823	–	. . . . .	. . . .	9.75	Roberts's period	Roberts, 189– ;	
5949	–	. . . . .	. . . .	$4^d\ 10^h\ 12^m.7$	*Algol*-type ; Rob. period	Roberts, 1891 ;	
6050	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1890 ;	Campbell
6062	–	1887 June 23	241 0446	+282 E	. . . .	Thome, 1892 ;	Fleming
6101	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1893 ;	
6207	–	1894 Apr. 30	=241 2949	+357 E?	. . . .	H.C.O., 1893 ;	Chandler
6275	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1892 ;	
6331	–	. . . . .	. . . .	. . . .	. . . .	H.C.O., 1895 ;	
6442	–	MIN. 1894 July $28^d\ 11^h\ 8^m.2$		$+3^d\ 23^h\ 49^m.545$ E	*Algol*-type, Hartwig's elements sec. min. about 45h. later	Muller and Kempf ; Chandler, 1894 ;	Yendell Hartwig
6446	–	. . . . .	. . . .	. . . .	. . . .	Espin, J. A. Parkhurst, 1895 ;	Yendell

No.	Star	1900.0		1900 Annual Variation		1855.0		Redness	Magnitude	
		R.A.	Decl.			R.A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
6500	R Pavonis	18 3 17	−63 38.1	+5.77	0.00	17 58 57	−63 38.2	–	7.6	9.0
6546	RS Sagittarii	10 59	−34 8.5	3.98	+0.01	18 8 0	−34 9.1	–	6.2	7.4
6613	*d* Serpentis	22 6	+ 0 8.2	3.07	0.03	19 48	+ 0 6.8	–	5.0	5.7
6653	T Lyrae	18 28 54	+36 55.0	2.10	0.04	18 27 19	+36 53.1	–	7.2	7.8
6854	Y Aquilae	19 2 16	+10 55.0	2.82	0.09	19 0 9	+10 51.0	–	5.3	5.7
6894	S Lyrae	9 6	+25 50.0	2.45	0.10	7 16	+25 45.6	–	9.0	12.0
6900	W Aquilae	10 0	− 7 13.2	3.23	0.10	7 34	− 7 17.6	–	7.5	11.2
6940	U Lyrae	16 37	+37 41.7	2.10	0.12	15 3	+37 36.6	–	8.3	<11
6943	T Sagittae	17 14	+17 28.1	2.68	0.11	15 13	+17 23.2	5.5*	8.3	9.9
7118	X Aquilae	16 51	+ 4 12.5	2.98	0.15	44 17	+ 4 5.9	–	8.5	<12
7122	S Pavonis	46 47	−59 27.2	5.10	0.15	42 57	−59 33.9	–	8.0	9.6
7139	RR Sagittarii	49 43	−29 27.2	3.74	0.15	46 54	−29 34.0	–	7.5	<12.5
7151	RU Sagittarii	19 51 50	−42 6.9	4.14	0.16	48 34	−42 13.9	–	8	<12.6
7240	RY Cygni	20 6 37	+35 38.8	2.26	0.18	20 4 55	+35 31.0	–	8.5	9.5
7245	R Telescopii	7 42	−47 18.	4.30	0.18	4 28	−47 26.	–	8.4	11.6
7247	RX Cygni	7 46	+47 30.9	1.84	0.18	6 24	+47 23.0	–	7.5	8.3
7255	RT Sagittarii	9 24	−39 29.	4.00	0.18	6 24	−39 37.	–	7.7	10.7
7260	Z Aquilae	9 51	− 6 27.4	3.20	0.18	7 27	− 6 35.4	–	9.0	11?
7351	RW Cygni	25 12	+39 38.8	2.18	0.20	23 34	+39 29.9	7.0*	7.7	10.5
7404	R Microscopii	33 58	−29 8.5	3.65	0.20	31 14	−29 17.8	–	9.2	<11
7448	W Aquarii	41 10	− 4 26.9	3.15	0.22	38 48	− 4 36.6	–	8.0	9.6?
7450	V Aquarii	41 46	+ 2 4.2	3.04	0.22	39 29	+ 1 54.6	2.5*	8.1	9.3
7458	V Delphini	43 14	+18 58.0	2.72	0.22	41 11	+18 48.3	–	8.9–9.1	12?
7492	RZ Cygni	48 31	+46 58.	2.01	0.22	47 0	+46 48.	–	9.1	13
7495	S Indi	48 59	−54 42.3	4.47	0.22	45 37	−54 52.	–	8.4	<12.4
7544	T Octantis	20 57 24	−82 30.	10.33	0.23	20 49 30	−82 40.	–	9.0	<12.5
7813	R Gruis	21 42 6	−47 22.	3.89	0.28	21 39 10	−47 34.	–	8.4	<12.5
7999	X Aquarii	22 13 12	−21 26.	3.31	0.30	22 10 47	−21 39.	–	8.4	11.6
8116	W Cephei	22 32 39	+57 54.4	2.28	0.31	22 30 56	+57 40.5	4.5*	7.3	8.3
8324	V Cassiopeae	23 7 22	+59 8.4	2.56	0.33	23 5 27	+58 53.8	–	8.3	12
8579	R Tucanae	52 12	−65 56.	3.17	0.33	49 48	−66 11.	–	10.2	<12.6
8604	S Phoenicis	53 54	−57 7.7	3.15	0.33	51 33	−57 22.9	–	7.2	8.7
8622	W Ceti	23 57 0	−15 13.9	+3.08	+0.33	23 54 41	−15 29.0	–	8.4	<12

UNCONFIRMED STARS.

It is not the intention in this Supplement to reconstruct, or bring up to date, the list of stars awaiting confirmation. But so many changes have been made in the lists given in *A.J.* 300 and 319, either by confirmation and removal to the above catalogue, or by satisfactory evidence of non-variability, that it will be a convenience to observers to have the following excised list of the stars in the former lists which still need examination. Only the names and places are here given. Reference can be made to *A.J.* 300 and 319 for the other details.

No.	Star	1855 R.A.	1855 Decl.	*A.J.*
		h m s	° ′	
(118)	ξ Tucanae	0 17 35	−72 40.	319
(571)	— Ceti	1 33 0	− 7 21.6	300
(780)	— Persei	2 6 53	+57 51.2	319
(1344)	— Persei	3 41 9	+35 16.7	300
(1636)	— Reticuli	4 32 3	−63 7.4	“
(1709)	— Tauri	42 20	+15 31.7	“
(1745)	(R) Eridani	48 48	−16 39.3	“
(1772)	(S) Eridani	53 11	−12 45.1	“
(1801)	— Camelopardalis	4 55 21	+68 28.2	“
(1945)	— Orionis	5 21 48	− 4 49.1	“
(1961)	δ Orionis	24 36	− 0 24.6	“
(1988)	— Orionis	5 29	− 5 34.	“
(2445)	— Monocerotis	6 45 17	− 6 58 2	“
(2659)	— Canis Majoris	7 21 3	−11 15.9	“
(2711)	(R) Puppis	35 15	−31 19.6	“
(2788)	(T) Puppis	7 43 11	−40 17.5	“
(2903)	— Cancri	8 1 16	+19 50.0	“
(3197)	— Cancri	8 50 23	+11 23.4	“

No.	M—m	Elements of Maximum, Greenwich M.T. Epoch (Cal.)	Julian	Period	Remarks	By whom Discovered ;	Confirmed
	d						
6500	–	...	...	...	...	H.C.O., 1893;	Cordoba Zones
6546	–	...	...	12^h; possibly *Algol*-type (Roberts)		Gould, 1874;	Roberts
6613	–	...	...	Short period	...	Müller & K., Yendell, 1894;	Chandler
6653	–	...	...	...	...	Birmingham, Safarik, 1886;	Yendell
6854	–	1894 Aug. 6	=241 3047.7	$+4^d.986$ E	...	Gould, Chandler, 1894;	Yendell
6894	–	...	...	...	...	Espin, 1893;	H. M. Parkhurst
6900	–	1893 July 1	241 2646	+490 E?	...	de Ball, 1893;	Schwab
6940	–	...	...	...	...	Espin, 1894;	Yendell
6943	65	1885 Dec. 10	240 9886	+177 E	...	Espin, 1886;	Yendell, Chandler
7118	–	1893 Aug. 8	241 2684	+356 E	...	H.C.O., 1894;	Yendell
7122	–	...	...	...	...	H.C.O., 1894;	
7139	140	1891 Sept. 26	241 2002	+338 E	...	Thome, 1891;	Fleming
7151	–	...	...	...	...	H.C.O., 1891;	
7240	–	...	...	...	...	Espin, 1886;	Yendell
7245	–	...	...	...	...	H.C.O., 1895;	
7247	–	...	...	...	Irregular	Deichmüller, 1893;	Yendell
7255	–	...	...	...	...	H.C.O., 1890;	
7260	–	...	...	...	...	de Ball, 1894;	Holetschek
7351	–	...	...	...	...	Espin, 1885;	Yendell
7404	–	...	...	...	...	H.C.O., 1894;	
7448	–	1888 Oct. 14	241 0925	+381 E	...	H.C.O., 1891;	Hartwig
7450	123:	1891 Jan. 15	241 1748	+245 E	...	de Ball, 1891;	Yendell
7458	–	1890 Dec. 20	241 1722	+540 E	...	H.C.O., 1891;	Yendell
7492	–	...	...	...	...	Espin, 1893;	H.M. Parkhurst, Hartwig
7495	–	...	...	...	...	H.C.O., 1895;	
7544	–	...	...	...	...	H.C.O., 1895;	
7813	–	...	...	...	...	H.C.O., 1895;	
7999	–	...	...	...	...	H.C.O., 1895;	
8116	–	1893 Nov. 10	241 2778.1	+ 6.44 E	Yendell's elements	Espin, 1885;	Yendell, J. A. Parkhurst
8324	105::	1893 Dec. 4	=241 2802	+224 E?	...	Anderson, 1893;	Hartwig
8579	–	...	...	...	...	H.C.O., 1892;	
8604	–	...	...	...	...	H.C.O., 1895;	
8622	–	...	...	...	...	Skinner, 1894;	Paul

No.	Star	1855 R.A. h	m	s	1855 Decl. °	'	A.J.
(3614)	(R) Velorum	10	0	42	—51	29.0	300
(4495)	β Corvi	12	26	47	—22	35.7	"
(4856)	— Virginis	13	26	58	—12	28.0	"
(4905)	— Canum Venat.	13	35	29	+29	6.7	"
(5076)	— Bootis	14	3	55	+10	30.1	"
(5159)	— Bootis	14	17	40	+26	22.0	319
(5481)	— Librae	15	11	15	+ 2	36.9	300
(5626)	— Librae	15	35	17	—10	27.7	"
(6088)	(V) Herculis	16	52	58	+35	17.4	"
(6470)	— Ophiuchi	17	56	7	+ 2	30.5	"
(6502)	*o* Herculis	18	1	54	+28	14.4	"
(6633)	(V) Sagittarii		22	54	—18	21.5	"
(6699)	— Draconis		35	38	+55	28.6	319
(6716)	— Lyrae		37	49	+36	49.4	"
(6749)	— Scuti		42	28	— 8	1.0	300
(6769)	— Sagittarii	18	45	30	—22	51.1	319
(6897)	— Cygni	19	8	27	+49	24.2	"
(6915)	— Sagittarii		9	53	—19	19.4	300
(7010)	— Sagittae	19	26	15	+17	26.0	300
(7182)	— Cygni		55	18	+30	25.6	"
(7205)	— Cygni	19	59	6	+36	24.8	"
(7238)	— Cygni	20	5	3	+47	25.4	"
(7268)	— Capricorni		8	37	—21	45.6	"
(7279)	— Cygni		11	53	+49	29.6	"
(7302)	— Capricorni		14	28	—16	28.2	"
(7194)	(R) Cephei		34	37	+88	41.0	"
(7435)	— Cygni		37	50	+46	30.1	"
(7452)	— Cygni		40	15	+40	33.7	"
(7481)	— Cygni		45	13	+33	57.1	"
(7502)	— Vulpeculae	20	48	24	+27	30.5	"
(7579)	63 f^2 Cygni	21	1	37	+47	3.9	"
(8006)	— Cephei	22	12	44	+56	15.7	"
(8104)	— Aquarii		28	17	— 8	20.8	"
(8106)	— Pegasi	22	28	48	+ 8	14.0	"
(8528)	19 Piscium	23	39	0	+ 2	40.8	"
(5)	— Ceti	23	58	30	—15	14.3	"

THE ORBIT OF COMET 1892 V.

By J. G. PORTER.

After the completion of my work on the orbit of Comet 1892 V, which appeared in this Journal, No. 310, a few further observations of the comet were published. Those made at Vienna, from Nov. 13 to Nov. 22 inclusive, coming as they do later than any others, excepting the single Lick observation of Nov. 21, must very materially strengthen the determination of the orbit. The fact of the comparatively large deviation of Mr. Barnard's observation of Nov. 21 is rendered certain by the practical accord of the Vienna observations, *inter se*, and I have therefore rejected the former and formed a new normal place from the latter alone. I have also included Strassburg observations of Oct. 20 and 21, and observations made at Copenhagen on Oct. 25 and 26.

The new resulting elements are as follows:

Epoch 1892 Oct. 22.5 Berlin M.T.

$$
\begin{aligned}
M_0 &= 352^\circ\ 1'\ 2''.1 \\
\pi &= 17\ \ 10\ \ 43.6 \\
\Omega &= 206\ \ 45\ \ 45.1 \\
i &= 31\ \ \ 8\ \ 59.8 \\
\varphi &= 35\ \ 13\ \ 15.5 \\
\log \mu &= 2.7586594 \\
\log a &= 0.5275644
\end{aligned}
$$

I append a table showing how closely these elements represent the individual observations.

Cincinnati, 1895 *May* 7.

Date	$\Delta\alpha \cos\delta$ ″	$\Delta\delta$ ″
Lick.		
Oct. 13	+ 6.1	+16.8
15	− 0.9	+ 7.3
16	− 5.8	+12.1
17	− 0.9	+13.5
18	− 9.5	+ 6.3
19	+ 0.3	+ 6.5
22	+10.4	+14.6
24	− 0.4	+ 6.2
24	+ 9.6	+11.5
25	+17.5	− 4.9
Nov. 7	− 5.7	+ 1.4
21	[+13.8]	[+13.3]
Pulkowa.		
Oct. 19	+ 3.3	− 1.3
20	+ 2.5	− 1.8
Northfield.		
Oct. 20	− 6.0	− 1.3
Vienna.		
Oct. 16	− 2.2	+ 1.6
20	+ 0.1	− 0.5
23	− 4.6	− 1.4
27	− 2.8	− 1.1
Nov. 7	+ 2.2	− 2.4
9	+ 0.3	+ 1.3
13	− 1.4	+ 2.7
17	− 2.4	+ 4.3

Date	$\Delta\alpha \cos\delta$ ″	$\Delta\delta$ ″
Vienna.		
Nov. 18	+ 3.9	− 1.6
22	+ 3.7	− 2.9
Paris.		
Oct. 17	+ 0.3	− 0.5
18	+ 1.8	− 0.4
20	− 1.9	− 0.6
21	+ 1.4	− 3.2
22	+ 7.8	−12.0
Hamburg.		
Oct. 17	− 6.8	− 0.5
18	+ 1.2	+ 2.5
Copenhagen.		
Oct. 18	+10.0	+ 2.4
25	+ 6.9	+ 2.6
25	+ 6.0	− 2.2
26	+ 8.4	− 1.9
Algiers.		
Oct. 18	+ 0.6	+ 0.7
Harvard.		
Oct. 19	+14.0	+ 1.0
Strassburg.		
Oct. 20	+ 2.4	− 1.7
21	− 1.5	− 6.3

MICROMETRICAL COMPARISONS OF POSITIONS OF *TITAN* WITH THOSE OF *TETHYS, DIONE AND RHEA*,

By ORMOND STONE.

The following observations were made with the twenty-six-inch refractor of the Leander McCormick Observatory. The angles given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction. The reductions were made by Mr. H. Y. Benedict.

Tethys–Titan.

1894	Eastern Time h m s	p	Eastern Time h m s	s
Mar. 14	13 7 9	108.47	. . .	. .
19	15 2 48	270.08	. . .	. .
23	13 30 41	356.36	13 36 47	48.84
26	11 43 11	79.50	11 57 41	57.60
27	11 50 20	86.51	12 15 36	229.45
	12 31 13	86.98	. . .	. .
30	11 58 16	123.57	12 16 25	57.43
	12 2 59	123.25	. . .	. .
Apr. 6	11 29 39	272.70	12 1 25	168.99
8	11 52 23	295.79	12 2 26	33.57
	12 32 50	295.61	12 18 49	33.87
Apr. 14	14 28 47	102.06	14 53 39	98.45
16	14 48 52	221.34	14 34 35	44.86
	. . .	. .	14 36 32	45.40
24	12 15 28	351.34	12 22 22	49.34
	12 36 7	354.86	12 23 30	49.31
May 3	9 29 7	250.50	9 41 29	115.93
	. . .	. .	9 43 47	115.98
10	9 6 41	318.77	9 16 48	35.83
	9 26 55	317.95	9 19 18	36.07
20	11 15 2	261.32	11 56 36	177.75
	12 21 14	261.46	12 5 54	177.38
June 3	12 25 50	137.89	12 32 11	48.58
	12 41 3	138.45	12 33 53	48.39
8	10 15 31	273.24	. . .	. .

Dione–Titan.

1894	Eastern Time h m s	p	Eastern Time h m s	s
Mar. 14	13 25 23	119.42	. . .	. .
	13 29 41	119.43	. . .	. .
19	15 14 37	266.75	. . .	. .
23	13 18 20	11.84	13 25 3	51.16

1894	Eastern Time h m s	p	Eastern Time h m s	s
Mar. 26	11 37 49	82.15	. . .	. .
30	11 54 9	139.83	12 25 29	*51.56
	12 8 47	141.11	. . .	. .
Apr. 2	11 39 34	258.83	11 58 24	91.42
6	11 13 11	281.70	11 45 26	104.22
	13 0 23	281.50	. . .	. .
8	11 46 16	320.63	11 58 4	32.41
	12 27 39	325.23	12 5 12	33.11
	. . .	. .	12 13 36	33.07
11	14 39 37	95.77	15 23 51	152.80
16	13 56 8	210.88	11 4 32	34.00
	14 13 25	210.14	14 7 32	34.26
22	12 56 41	284.97	13 36 39	113.95
May 3	8 15 10	231.90	8 19 43	44.42
	8 26 21	231.81	8 21 30*	44.26
9	9 41 47	305.83	9 50 44	50.41
	10 1 4	305.93	9 52 57	50.33
June 15	9 2 54	86.54	9 20 51	122.90
	9 46 13	86.50	9 23 25	123.10

---

* or 54.27.

Rhea–Titan.

1894	Eastern Time h m s	p	Eastern Time h m s	s
Mar. 7	16 44 14	295.80	16 59 3	89.92
	17 36 52	297.22	17 21 39	89.69
12	13 39 6	87.28	14 25 2	114.62
	14 9 16	87.48	14 38 12	114.48
13	13 57 45	97.56	15 0 28	219.80
	. . .	. .	15 3 53	219.82
19	15 9 23	264.99	15 44 20	19.39
	. . .	. .	16 0 8	20.00
21	13 54 18	107.91	14 3 30	121.38
	14 26 14	108.50	14 5 38	120.24
	. . .	. .	14 13 49	120.15
	. . .	. .	14 16 49	119.66
23	13 47 31	291.11	13 58 1	59.72
	. . .	. .	14 5 3	60.15
24	11 15 35	306.06	. . .	. .
26	11 13 16	80.79	. . .	. .
27	12 29 31	91.06	12 11 33	229.47
	12 40 34	91.15	. . .	. .
Apr. 2	11 29 22	258.38	12 18 27	104.69
6	11 35 37	270.94	12 15 8	216.60
	13 10 6	271.45	. . .	. .
8	10 41 39	346.29	11 2 56	59.63
	11 26 6	351.14	11 35 1	58.93
14	14 33 17	102.02	14 58 59	182.33
16	10 58 48	240.43	10 7 50	69.72
	11 20 22	240.69	10 9 46	69.28
	16 0 40	244.46	. . .	. .
22	12 47 25	290.55	13 15 17	86.25
	13 57 9	291.50	13 19 25	85.86
24	11 47 57	285.76	11 58 34	82.45
	12 7 0	285.64	12 0 37	82.65
27	10 57 56	84.54	11 8 38	123.04
	11 38 35	84.71	11 28 21	122.48
29	14 33 42	278.43	14 42 16	91.37
	14 54 3	278.32	14 46 4	91.32
30	13 31 6	93.80	13 40 56	108.48
	13 49 25	93.90	13 43 36	108.91
May 3	9 4 22	240.45	9 14 21	114.45
	9 23 14	240.99	9 16 8	114.53
9	10 25 24	287.46	10 37 14	143.99
	. . .	. .	10 40 35	143.63
10	9 30 51	31.77	9 38 25	60.01
	9 48 43	32.96	9 40 9	59.88
17	9 8 21	175.37	9 13 53	41.94
	9 20 45	175 64	9 17 40	41.90
20	11 5 54	241.27	11 19 4	83.24
	11 35 30	242.05	11 25 48	83.55
June 4	10 14 31	252.67	10 31 57	152.51
	10 45 21	253.05	10 34 3	152.95
8	9 39 59	267.09	9 53 29	202.97
	10 8 49	267.23	9 55 59	202.51
13	9 29 20	70.61	. . .	. .
14	9 25 1	74.59	9 34 38	110.24
	9 44 19	74.91	9 36 26	110.82
22	10 39 5	262.95	10 48 7	239.53
	11 10 17	263.20	10 51 35	239.61
27	8 28 25	288.42	8 42 8	95.37
	. . .	. .	8 46 47	94.90

NEW ELEMENTS OF PLANETS (313) AND (346),

BY LEWIS BOSS.

Assistants OGBURN and ROY of this Observatory, during a course of instruction, have computed elements of *Chaldaea* (313), from observations made at the Dudley Observatory during the opposition of 1894, which are published in *A.J.*, 339. The observations of June 28, July 25 and Aug. 9, are exactly represented, but the representation of other observations leaves something still to be desired. In view of the computations of Mr. BERBERICH (*A.J.* 340), it did not seem worth while to continue this investigation. The new elements are these:

Epoch = 1894 July 14.0, Berlin M.T.

$$M = 146^\circ\ 20'\ 12''.2$$

$$\left.\begin{aligned} \omega &= 313\ 44\ 23.9 \\ \Omega &= 176\ 39\ 42.1 \\ i &= 11\ 34\ 57.4 \end{aligned}\right\}1894.0$$

$$\varphi = 10\ 27\ 7.4$$

$$\mu = 968''.2209$$

$$\log a = 0.376022$$

Assistant ROY having experienced some difficulty in finding planet (346) from the elements in the *Jahrbuch*, has computed new elements of this planet under my instruction. The following table indicates the basis of his computations, and exhibits the results of a comparison of the corrected observations with an ephemeris computed from the finally deduced elements. Many of the star-places as published received important corrections. Differences inclosed in brackets had no influence in the formation of normal places; some other observations received small weight.

Comparison of Observations with Computation (O — C).

Place	Berlin Time 1892-3	$\Delta\alpha$ s	$\Delta\delta$ ″	Publication
Nice	Nov. 27	−0.03	− 0.3	*B.A.*, X. 59
Nice	Nov. 29	−0.04	− 0.2	" " "
Nice	Dec. 5	+0.08	+ 1.1	" " "
Nice	Dec. 19	[+0.16]	[+ 0.5]	" " "
Hamburg	Jan. 7	−0.09	+ 2.0	*A.N.* 134, 383
Hamburg	Jan. 9	+0.30	+ 1.2	" " "
Hamburg	Jan. 10	+0.05	+ 0.5	" " "
Padua	Jan. 12	+0.16	− 7.1	*A.N.* 3164
Rome	Jan. 13	+0.13	− 1.3	*A.N.* 3183
Padua	Jan. 13	+0.11	+ 1.6	*A.N.* 3164
Algiers	Jan. 13	−0.03	− 2.4	*B.A.*, X. 179
Algiers	Jan. 14	−0.17	− 1.0	" " "
Padua	Jan. 20	[+0.52]	[+ 1.7]	*A.N.* 3164
Padua	Jan. 23	[−0.34]	[+18.0]	" "
Nice	Feb. 1	[+0.06]	[+ 1.9]	*B.A.*, X. 323
Nice	Mar. 7	0.00	0.0	" " "

The computation resulted in the following

Elements of Planet (346).

Epoch = 1893 Jan. 13.5 Berlin M.T.

$$\begin{aligned} M &= 42^\circ\ 25'\ 9''.2 \\ \omega &= 286\ \ 56\ \ 55.6 \\ \Omega &= 92\ \ 20\ \ 25.6 \\ i &= 8\ \ 45\ \ 25.4 \end{aligned} \Bigg\} 1893.0$$

$$\begin{aligned} \varphi &= 5\ \ 56\ \ 6.5 \\ \mu &= 758''.9757 \\ \log a &= 0.4465192 \\ m_0 &= 11^M.5;\ g = 7^M.5 \end{aligned}$$

The planet was found on April 21, 1895, 7′ south, and $1^m.3$ following the predicted place. A small change in μ sufficed to produce a fair representation of this observation.

MERIDIAN OBSERVATIONS OF (6) *HEBE*,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9-INCH TRANSIT CIRCLE.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

Date, 1895	Observer	α	Corr. to *B.J.*	δ	Corr. to *B.J.*	log $p\Delta$ for δ
		h m s	s	° ′ ″	″	
March 6	King	11 17 54.89	+3.39	. . . .	. .	. . .
21	Skinner	11 5 13.56	+3.35	+17 46 8.1	−4.1	0.4993
22	Skinner	11 4 26.99	+3.35	+17 52 59.4	−3.6	0.4971
28	Skinner	11 0 6.51	+3.27	+18 29 30.9	−3.0	0.4847
29	Skinner	10 59 26.73	+3.28	+18 34 49.4	−3.1	0.4829

These observations have been corrected for parallax.

NOTATION AND NOMENCLATURE OF ASTEROIDS.

Mr. Berberich has kindly communicated the numbers assigned to small planets discovered since (390) [See *A.J.*, no. 329].

	1894-5			
BD	Nov. 1	Wolf,	Heidelberg,	orbit unknown
BE	Nov. 1	"	"	(391)
BF	Nov. 4	"	"	(392)
BG	Nov. 4	"	"	(393)
BH	Nov. 19	Borrelly.	Marseilles,	(394)
BJ	Nov. 24	Charlois.	Nice.	(369) *Aëria*
BK	Nov. 30	"	"	(395)
BL	Dec. 1	"	"	(396)
BM	Dec. 19	"	"	(397)
BN	Dec. 28	"	"	(398)
BO	Apr. 9	Roberts,	—	orbit unknown
BP	Feb. 23	Wolf,	Heidelberg,	(399)
BQ	Feb. 23	"	"	orbit unknown
BR	Feb. 25	"	"	(379)
BS	Feb. 25	"	"	(333) *Badenia*
BT	Mar. 16	"	"	(401)
BU	Mar. 15	Charlois.	Nice.	(400)
BV	Mar. 15	Wolf.	Heidelberg,	(203) *Pompeia*
BW	Mar. 21	Charlois,	Nice.	probably (402)

Mr. Berberich suspects that a more recently discovered asteroid, *BX*, may prove to be the long-lost (156) *Xanthippe*.

Names have been assigned as follows:

No. 392	*Wilhelmina*	No. 401	*Ottilia*

CORRIGENDA.

No. 345, p. 65, col. 1. l. 17, *for* circle *put* cycle.
p. 72, in Ephemeris of Variables, June 4, δ *Librae*, *for* 10ʰ *put* 19ʰ.

No. 345, p. 72, June 25, *U Ophiuchi*, *for* 19ʰ *put* 9ʰ.
p. 72, July 29, 30, lines 5 and 4 from below, transpose the names *U Ophiuchi* and *U Cephei*.

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Notation and Nomenclature of Asteroids.
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Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed June 14.*

THE

ASTRONOMICAL JOURNAL.

No. 348.

VOL. XV. BOSTON, 1895 JULY 3. NO. 12

OBSERVATIONS OF SMALL PLANETS,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 9.6-INCH EQUATORIAL,

By Prof. EDGAR FRISBY, U.S.N.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1894 Washington M.T.		*	No. comp.	Planet — *		Planet's Apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
				(241) *Germania.*					
	h m s			m s	′ ″	h m s	° ′ ″		
July 26	10 36 11.1	1	25 . 5	−0 9.34	− 1 18.3	19 34 1.54	−18 19 16.6	n8.9108	0.8463
Aug. 7	10 45 13.4	2	12 . 3	+0 43.37	+12 57.1	19 25 11.13	−18 13 45.6	8.5700	0.8657
				(119) *Althaea.*					
Oct. 1	11 44 2.3	3	7 . 2	+2 1.19	+ 7 17.3	22 35 32.42	− 3 27 1.5	9.3381	0.7695
2	10 38 13.7	3	20 . 4	+1 37.40	+ 1 11.7	22 35 8.63	− 3 33 7.1	9.0023	0.7732
5	10 25 51.5	3	13 . 5	+0 30.24	−16 42.3	22 34 1.46	− 3 51 1.1	9.0222	0.7755
6	10 42 44.6	4	20 . 4	−1 38.69	+ 8 49.3	22 33 43.37	− 3 57 11.0	9.1544	0.7757
15	10 52 52.3	5	20 , 4	−0 14.35	+ 3 46.4	22 32 5.06	− 4 42 21.0	9.3599	0.7780
16	11 14 53.0	5	20 , 4	−0 16.99	− 0 27.5	22 32 2.42	− 4 46 34.9	9.4358	0.7508
17	9 18 3.5	5	20 , 4	−0 17.99	− 4 9.3	22 32 1.41	− 4 50 16.7	8.8345	0.7840
19	11 18 9.0	5	20 . 4	−0 15.14	−11 55.7	22 32 4.25	− 4 58 3.1	9.4734	0.7754
20	10 46 28.6	5	10 . 2	−0 11.10	−15 21.6	22 32 8.29	− 5 1 28.0	9.4022	0.7789
				(87) *Sylvia.*					
Oct. 31	10 21 54.4	6	20 . 4	−1 23.53	−10 45.1	2 18 31.84	+ 2 57 27.6	n8.4710	0.7329
Nov. 1	10 26 40.5	6	20 , 4	−2 8.41	−11 58.3	2 17 46.98	+ 2 56 14.4	n9.1128	0.7144
3	10 1 46.8	7	20 . 4	+0 55.47	−11 18.5	2 16 16.18	+ 2 53 58.6	n9.2012	0.7153
				(190) *Ismene.*					
Nov. 1	11 47 43.7	8	20 . 4	+0 53.54	+ 6 39.9	2 20 57.30	+ 8 21 36.9	8.4068	0.6499
5	11 4 55.3	8	15 . 3	−0 21.11	− 1 32.0	2 19 42.67	+ 8 13 25.0	n8.6294	0.6519
				(95) *Arethusa.*					
Nov. 19	12 0 42.6	9	18 . 4	+0 35.45	+ 7 35.2	4 43 5.97	+21 15 31.7	n8.9896	0.4312
21	12 32 24.5	9	15 . 3	−1 6.90	− 6 20.1	4 41 23.65	+21 1 36.4	n7.9508	0.4288
Dec. 3	10 27 48.3	10	10 . 2	+1 18.20	− 1 15.7	4 30 52.36	+19 38 49.9	n9.1745	0.6492
14	8 44 12.1	11	14 . 3	+2 2.96	−12 0.6	4 21 48.78	+18 25 40.5	n9.3866	0.4912
15	8 4 11.7	11	19 , 4	+1 19.40	−18 5.2	4 21 5.28	+18 19 35.9	n9.4899	0.5531
17	9 47 1.1	12	20 . 4	+4 6.89	− 3 28.7	4 19 34.47	+18 6 52.4	n8.9856	0.4984
19	8 26 46.2	13	20 . 4	+2 54.59	− 5 59.9	4 18 15.56	+17 55 4.1	n9.5252	0.5717
				(134) *Sophrosyne.*					
Dec. 5	10 8 16.6	14	20 . 4	−1 19.36	+ 3 45.4	4 53 54.60	+42 58 22.9	n9.4478	n9.2133
14	10 32 54.3	15	14 . 3	+1 52.07	− 1 52.8	4 42 40.41	+42 35 8.7	n8.9729	n9.7360
15	8 43 57.9	15	15 , 3	+0 46.52	− 5 35.6	4 41 34.87	+42 31 26.1	n9.4504	9.3818
17	10 52 28.6	16	9 , 2	−1 34.53	+ 5 38.0	4 39 10.56	+42 22 20.5	n6.6910	n9.7523
19	9 31 33.5	16	15 . 3	−3 42.06	− 3 48.2	4 37 3.04	+42 12 55.0	n9.3186	n9.5066
				(26) *Proserpina.*					
Dec. 5	11 42 48.4	17	16 . 2	+0 24.33	−17 26.5	4 56 48.19	+25 20 18.7	n8.4944	0.3108
14	9 54 41.9	18	12 . 3	+0 24.75	+ 1 55.8	4 47 36.54	+25 13 35.2	n9.2288	0.3480
17	11 26 23.3	18	15 . 4	−2 36.76	− 1 11.6	4 44 35.06	+25 10 27.8	8.7967	0.3203
19	10 28 11.8	18	15 . 3	−4 29.32	− 3 19.3	4 42 42.50	+25 8 20.2	n8.6386	0.3190

1894-95 Washington M.T.	*	No. comp.	Planet — * Δα	Planet — * Δδ	Planet's Apparent α	Planet's Apparent δ	log pΔ for α	log pΔ for δ
				(28) *Bellona.*				
	h m s		m s	′ ″	h m s	° ′ ″		
Dec. 14 11 51 –	19	3	+0 42	+ 5 6.7	5 12 11	+ 8 53 12.2	. .	. .
17 11 56 39.0	20	15 , 3	−0 31.67	+ 1 11.7*	5 9 25.18	+ 8 57 52.9	8.8667	0.6532
19 11 4 19.5	20	20 , 4	−2 21.63	+ 4 16.8	5 7 38.23	+ 9 0 57.9	*n*8.2300	0.6412
				(58) *Concordia.*				
Jan. 19 11 20 13.8	21	20 , 4	+2 0.48	+ 7 14.0	8 25 22.26	+14 11 3.9	*n*9.1412	0.5730
26 10 8 49.8	22	20 , 4	+0 32.98	+ 0 40.8	8 18 59.68	+14 43 28.8	*n*9.3091	0.5753
				(11) *Parthenope.*				
Jan. 31 11 51 17.8	23	20 , 4	+1 12.56	+ 1 34.7	7 27 35.15	+21 2 32.2	9.1604	0.4298
Feb. 2 11 27 31	24	2	. . .	−10 14.8	. . .	+21 9 25.3	. .	0.4379
				(6) *Hebe.*				
Feb. 23 10 49 27.4	25	18 , 4	−0 19.61	− 3 37.7	11 27 20.46	+13 49 31.6	*n*9.4412	0.6050
28 10 42 21.9	26	5 , 1	−2 3.82	+ 4 11.4	11 23 10.95	+14 41 5.7	*n*9.4004	0.5868
Mar. 21 11 18 51.7	27	30 , 6	+2 3.01	− 0 4.9	11 5 13.55	+17 46 13.5	8.3880	0.6880
22 11 29 42.1	27	20 , 4	+1 15.58	+ 6 47.4	11 4 26.12	+17 53 5.9	8.7533	0.6831
25 10 2 57.4	28	19 , 4	+1 1.70	− 6 5.2	11 2 14.06	+18 12 4.2	*n*8.9841	0.5000
28 10 39 30.5	28	20 , 4	−1 5.90	+11 22.1	11 0 6.44	+18 29 31.3	7.8816	0.4848

* Probably 1 revolution = 24″.0 wrong.

Mean Places for 1894.0 and 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 34 7.45	+3.43	−18 7 58.2	− 0.1	Weiss's Argelander 15597
2	19 24 24.31	+3.45	−18 26 41.7	− 1.0	Bonn VI, 19h 53
3	22 33 27.84	+3.39	− 3 34 36.4	+17.6	Weisse-Bessel XXII, 664
4	22 35 18.67	+3.39	− 4 6 18.0	+17.7	Schjel. 9279
5	22 32 16.11	+3.30 +3.28	− 4 46 24.4	+17.0 +17.0	⅓(2 Yarnall+Grant)
6	2 19 51.58	+3.79 +3.81	+ 3 7 47.6	+25.1 +25.1	Schjel. 687
7	2 15 18.64	+3.87	+ 3 4 52.2	+25.1	Weisse-Bessel II, 201
8	2 19 59.93	+3.83 +3.85	+ 8 14 31.8	+25.2 +25.2	Weisse-Bessel II, 287
9	4 42 26.07	+4.45 +4.48	+21 7 39.5	+17.0 +17.0	Weisse-Bessel IV, 899. 900
10	4 29 29.82	+4.34	+19 39 44.0	+21.6	Grant 1106
11	4 19 41.17	+4.65 +4.71	+18 37 22.1	+19.0 +19.0	Yarnall 1947
12	4 15 22.93	+4.65	+18 10 1.7	+19.4	Weisse-Bessel IV, 270
13	4 15 16.33	+4.64	+18 0 44.6	+19.4	Weisse-Bessel IV, 267
14	4 55 8.29	+5.67	+42 54 21.9	+15.6	Bonn Zones IV, 4064
15	4 40 42.61	+5.73	+42 36 42.9	+18.6	Bonn Zones 3850
16	4 40 39.36	+5.73 +5.74	+42 16 23.8	+18.7 +19.4	Bonn Zones 3849
17	4 56 18.99	+4.87	+25 37 29.4	+15.8	Weisse-Bessel IV, 1220 emendata
18	4 47 6.84	+4.95 +4.98	+25 11 22.4	+17.0 +17.1	Weisse-Bessel IV, 1002.3
19	5 11 24.20	+4.53	+ 8 47 52.5	+13.0	Weisse-Bessel V, 195
20	5 9 55.29	+4.56 +4.57	+ 8 56 27.5	+13.7 +13.6	Weisse-Bessel V, 164
21	8 23 19.98	+1.80	+14 3 48.6	+ 1.3	Bonn VI, +14°1901
22	8 18 24.85	+1.91	+14 42 46.9	+ 1.1	Bonn VI, +14°1885
23	7 16 20.66	+1.93	+21 0 53.0	+ 4.5	Bonn VI, +21°1631
24	. . .	. . .	+21 19 35.6	+ 4.5	Weisse-Bessel VII, 693
25	11 27 38.00	+2.07	+13 53 20.9	−11.6	Schjel. 4176
26	11 25 12.65	+2.12	+14 37 5.0	−10.7	Bonn VI, +14°2395
27	11 3 8.20	+2.34	+17 16 27.6	− 9.2	Paris Lalande 13610
28	11 1 10.03	+2.33 +2.31	+18 18 18.0	− 8.6 − 8.8	Paris Lalande 13566

MAXIMA AND MINIMA OF VARIABLE STARS OBSERVED IN 1894–1895,

BY G. GRUSS AND V. LASKA.

The following observations were made, like our previous series (*A.J.* no. 318), with a 8-inch equatorial instrument of the Bohemian University Observatory (Prague VII, 80), by **Argelander**'s method. The magnitudes are expressed in the **Argelander** scale.

1) 103. *T Andromedae.*

By twenty observations, from 1894 September 15 to 1895 Feb. 22, we obtain

Max.: 1894 Dec. 3, $8^M.4$.

2) 678. *U Persei.*

U Persei was observed from 1894 March 12 to 1894 April 9. In the beginning $8^M.6$, and in the end $7^M.7$.

3) 906. *R Trianguli.*

By thirty-one observations, between 1894 Dec. 9 and 1895 March 30, we deduce

Max.: 1895 Feb. 9, $6^M.6$.

4) 1113. *U Arietis.*

This star was under observation from 1893 Sept. 15 to 1895 Jan. 14, the observations numbering twenty-eight. These give

Max.: 1893 about Nov. 9, $8^M.6$
Max.: 1895 about Nov. 1, $7^M.0$

5) 1367. *X Tauri.*

We observed this star from 1893 Sept. 15 to 1894 April 3 (seventeen times), and from 1894 Oct. 20 to 1895 Feb. 17 (nine times), about $8^M.0$. The change of light was irregular ($\pm 0^M.2$).

6) 1574. *W Tauri.*

Fifteen observations of this star, from 1894 Aug. 27 to 1895 Jan. 15, show a maximum,

1894 Nov. 11, $8^M.8$.

7) 1577. *R Tauri.*

From 1894 Feb. 12 to 1895 April 8, thirty observations were made, giving

Max.: 1894 April 6, $7^M.4$
Max.: 1895 March 15, $9^M.2$

8) 1582. *S Tauri.*

Twenty-five observations, between 1894 Jan. 12 and 1895 Feb. 27, give the following epochs:

Max.: 1894 Feb. 4, $9^M.3$
Max.: 1895 Jan. 25, $9^M.3$

9) 2100. *U Orionis.*

By twenty-eight observations, from 1895 Jan. 23 to 1895 March 31, we obtain

Max.: 1895 Feb. 25, $6^M.8$

10) 3186. *T Cancri.*

This star was observed twice.

1894 April 26, $8^M.3$
1894 May 6, $8^M.3$

11) 3567. *V Leonis.*

This star was observed three times.

1894 March 23, $8^M.8$
March 26, $8^M.9$
May 6, $7^M.3$

12) 4731. *S Canum Venaticorum.*

We observed this star from 1893 Aug. 23 to 1893 Dec. 2 (sixteen times), from 1894 Jan. 22 to 1894 Dec. 29 (seventeen times) about $8^M.8$. The star was constant.

13) 4948 *R Canum Venaticorum.*

By nineteen observations, from 1894 June 22 to 1894 Nov. 29, we obtained

Max.: 1894 Aug. 26, $6^M.9$.

14) 5194. *V Bootis.*

Twenty-two observations of *V Bootis*, from 1894 May 28 to 1894 Nov. 24, indicate a maximum of $7^M.6$, occurring 1894 July 3.

15) 5438. *Y Librae.*

Since 1894 Feb. 8, we have observed this star up to 1894 Aug. 15, eleven times; it was hardly seen.

16) 5667. *R Coronae.*

Was observed by **Laska** from 1894 July 13 to 1894 Dec. 14. It rose rapidly from 1894 Aug. 15. A maximum $5^M.8$ was passed on 1894 Oct. 22. The observations number thirteen.

17) 5758. *X Herculis.*

We have twenty-four observations of *X Herculis* from 1894 June 23 to 1894 Dec. 3. The observations of this star show two maxima and two minima.

Max.: 1894 July 11, $6^M.4$
Min.: 1894 Sept. 1, $6^M.9$
Max.: 1894 Oct. 15, $6^M.3$
Min.: 1894 Dec. 3, $6^M.9$

18) 5889. *U Herculis.*

Was observed from 1894 July 22 to 1894 Oct. 7. The brightness at the first-named date was $7^M.3$; at the last observation, $9^M.5$. No maximum.

19) 5950. *W Herculis.*

During the year 1894 we have observed *W Herculis* thirty times, from 1894 June 22 to 1894 Dec. 13.

Max.: 1894 Oct. 21, $7^M.9$.

20) 6005. *S Draconis.*

From 1894 June 28 to 1894 Dec. 9, nineteen observations of this star were obtained: from these we have determined

Max.: 1894 Oct. 26, $8^M.2$.

21) 6442. *Z Herculis.*

We observed *Z Herculis* twenty-seven times on the 18th September, 1894, from $7^h 57^m$ to $11^h 16^m$, and deduce

Min.: 1894 Sept. 18. $9^h 36^m.0$ Prague M.T.

22) 6682. *X Ophiuchi.*

By forty-three observations, from 1894 June 20 to 1894 Dec. 13, we obtain a well determined

Max.: 1894 Sept. 11. $7^{M}.0$.

23) 6726. *T Aquilae.*

This star was under observation from 1894 June 20 to 1894 Dec. 13, the observations numbering forty-three. These give one maximum 1894 June 28, $8^{M}.9$, and one minimum 1894 Nov. 9, $9^{M}.7$. The first not especially good.

24) 6834. *V Aquilae.*

From 1894 June 1 to 1894 Dec. 13, we have thirty-five observations without results. This irregular red star was during the interval $7^{M}.3$—$7^{M}.7$.

25) 6849. *R Aquilae.*

R Aquilae was observed thirty-two times from 1894 May 28 to Oct. 23. We find a well determined

Max.: 1894 July 5. $6^{M}.2$.

and one secondary maximum after the principal.

26) 6900. *W Aquilae.*

W Aquilae was 1894 July 29, $10^{M}.1$, Aug. 6, $10^{M}.0$, and from 1894 Sept. 18 to 1894 Dec. 13, $8^{M}.2$, with small variations $0^{M}.1$—$0^{M}.2$.

27) 6943. *T Sagittae.*

Thirty-three observations of *T Sagittae*, from 1894 June 22 to Dec. 9, show a maximum

1894 July 21. $8^{M}.6$.

At the last observation the star's light had decreased to $9^{M}.7$. The brightness when first observed was estimated $9^{M}.2$.

28) 7045. *R Cygni.*

Eight observations of *R Cygni*, from 1894 May 9 to 1894 Oct. 21, indicate a maximum of $8^{M}.0$, occurring 1894 June 1. The magnitude when last observed was $9^{M}.2$.

29) 7085. *RT Cygni.*

Since 1894 July 29 we have observed *RT Cygni* twenty-three times to 1895 Feb. 8. It decreased steadily from the first observed magnitude, $7^{M}.8$, to minimum 1894 Oct. 15, $10^{M}.0$, and increased steadily to maximum 1894 Dec. 17, $6^{M}.6$.

30) 7261. *R Delphini.*

We have twenty-seven observations of this star from 1894 June 20 to 1894 Oct. 21. A maximum was passed on 1894 July 21, $8^{M}.1$. The brightness of last observation was $9^{M}.8$.

31) 7428. *V Cygni.*

From 1894 July 13 to 1895 Feb. 8, this star was observed twenty-four times. During the whole interval the star was about $9^{M}.5$.

32) 7448. *W Aquarii.*

W Aquarii was observed thirteen times, from 1894 July 13 to 1894 Nov. 24. The brightness when first observed, was estimated as $10^{M}.0$; at the last observation, 11^{M}–12^{M}.

33) 7450. *V Aquarii.*

By fourteen observations, between 1894 July 13 and 1894 Dec. 9, we deduce, not certainly,

Min.: 1894 Oct. 21, $9^{M}.2$.

The light at the first and last observation was about $8^{M}.5$.

34) 7456. *RR Cygni.*

From 1894 Aug. 2 to 1895 Feb. 8, twenty-nine observations were made, giving a maximum about middle of August, 1894.

35) 7795. *RV Cygni.*

This irregular star was observed from 1894 July 13 to 1895 Feb. 8, thirty-three times. These give

Min.: 1894 Sept. 28, $8^{M}.6$
Min.: 1894 Dec. 17, $8^{M}.6$

36) 8068. *S Lacertae.*

S Lacertae was observed thirteen times from 1894 Aug. 27 to 1894 Nov. 22. We find quite certainly,

Max.: 1894 Sept. 17, $7^{M}.6$.

The brightness at last observation was $9^{M}.7$.

ON THE LIGHT-CURVE OF 103 *T ANDROMEDAE.*

By PAUL S. YENDELL.

Since the appearance of my paper on *T Andromedae* in No. 335 of this Journal, four other determinations of the same maximum there published have appeared, as follows: In *Popular Astronomy*, March 1895, J. A. PARKHURST, 14 observations, 1894 Dec. 3, and F. F. ARNOLD, 11 observations, 1894 Dec. 4; in the *Astrophysical Journal*, April 1895, Prof. E. C. PICKERING, from 12 photographic plates, 1895 Dec. 10; and by H. M. PARKHURST, *Astronomical Journal*, No. 346, from 11 photometric observations, 1894 Dec. 6.

My own determination, published in the paper first above referred to, was, from 34 observations, 1894 Dec. 4. The mean of all these dates, assigning them weights in proportion to the number of observations from which they were respectively deduced, is 1894 Dec. 5, and fully confirms my assumption that my own date is not in error by more than a single day.

In the *Astrophysical Journal*, for April 1895, Prof. PICKERING has published his photographic measures of this star since 1891, with the dates of maxima deduced by him from the same, which he considers confirmatory of his original published period of 281 days, although the last, which is the only well-determined one of the entire series, is sharply discordant, showing a residual of —26 days from the time of maximum computed from the elements published in the *Astronomische Nachrichten*, Vol. 134, p. 347. Inasmuch as they are deduced by a law which Prof. Pickering himself expressly characterizes as "assumed," from an inadequate number of observations,—in one case from a single measure at nearly minimum light, and in all but one by the use of values at a part of the light-curve of which we know almost nothing—the remaining dates are at least as unsatisfactory as those of mine, found from the same measures by the use of a curve actually observed, which dates he stigmatizes as "illusory." I am aware that, so far as my own dates were deduced from the same measures, they are open in part to the same objections; but they were put forward only as rough approximations from insufficient and uncertain data, and not, as claimed for the Harvard results, as possessing an accuracy hitherto unattained. Moreover, they were fairly accordant among themselves, and well satisfied by the elements deduced from them, which, in spite of Prof. Pickering's assertion to the contrary, is not the case with his results. To state baldly that the period has changed is a begging of the entire question, and requires more proof than is furnished by the bare assertion.

The period of 281 days, if carried back to the dates of the Bonn and Cambridge observations in 1855 and 1878, at both of which times the star must have been very near a maximum, fails to account for them by nearly a month in each case, the residuals having opposite signs; the 265-day period, however, starting from the well-fixed date of maximum, 1894 Dec. 5, accounts for them as nearly as the uncertainty of the actual dates of maxima allows. No elements which fail to account for these dates can be satisfactory.

Until further material shall have accumulated from the observations of the next two or three maxima, however, it seems useless to enter at any length upon a discussion of the elements.

Following the observations from which my published maximum was deduced, I secured six more, the last date on which a regular comparison was made being 1895 Feb. 13. The star was seen on Feb. 20, but only an eye-estimate of magnitude was made, and neither this observation nor that of 1894 Oct. 22 have been included in the reductions.

After the series was finally closed, all the observations were carefully reduced anew, the light-scale and magnitude-scale being carefully revised. The graphic work of the reduction was carried out with extreme care, and every possible precaution used to avoid the presumable influence of the former reduction. The resulting date of maximum fully confirmed the original one, being Dec. 4.5.

The readings in the column *C* of the table of observed magnitudes are taken from the light-curve as finally drawn.

The comparison-stars used, with their DM. magnitudes and those deduced from my observations, and the light-scale, are given in the following table.

		Mag. DM.	Mag. *Y*	Light
b =	DM. 26°42	8.1	8.10	32.5
a =	40	7.5	8.18	31.7
d =	37	8.8	8.58	27.6
g =	27°47	8.5	8.26	30.9
e =	26°52	9.2	9.20	21.1
c =	47	9.1	9.07	22.4
h =	46	9.4	9.60	16.8
f =	25°40	9.5	10.20	10.0

The average value of the step is 0M.09.

The following table contains the dates of observation, the readings from the observed curve as described, my own observed magnitudes, the H.C.O. photographic measures, and the observed magnitudes of Messrs. J. A. Parkhurst and Arnold. The weights are simplified from my own observing scale, and are assigned to the last two series of observations on the same rules as to my own, Mr. Arnold's being given half-weight only as being a less experienced observer. I have not attempted to assign weights to the Harvard measures.

The headings of the columns are as follows; *Y* contains my own observations; *P* the H.C.O. photographic measures, to which has been applied the correction —0m.6, as mentioned below; *Pa* those of Mr. J. A. Parkhurst, and *A* those of Mr. Arnold.

The second place of decimals in the magnitudes and residuals is not significant, and has been retained for the sole object of securing an unbiased estimate of the mean and probable errors.

	C	*Y*			*P*	*Pa*		*A*	
1894	m	m	w	d	m	m	w	m	w
Oct. 18	10.62	10.58	½	—0.04	10.5	–	–	–	–
19	–	10.58	½	+0.03	10.4	–	–	–	–
20	–	–	–	–	10.2	–	–	–	–
23	10.27	–	–	–	–	–	–	–	–
27	–	10.02	1	—0.02	–	–	–	–	–
28	9.94	9.86	½	—0.08	–	–	–	–	–
31	–	9.75	1	0.00	–	–	–	–	–
Nov. 2	9.62	–	–	–	–	–	–	–	–
Nov. 6	–	–	–	–	9.6	–	–	–	–
7	9.31	–	–	–	–	–	–	–	–
12	9.02	–	–	–	–	–	–	–	–
15	–	–	–	–	–	9.14	1		–
16	–	9.03	1	+0.22	–	–	–	–	–
17	8.76	–	–	–	–	–	–	8.65	¼
19	–	8.62	1	—0.05	–	–	–	–	–
20	–	8.45	1	—0.18	–	8.88	1	8.58	½

	C	*Y*			*P*	*Pa*		*A*	
1894	m	m	w	d	m	m	w	m	w
Nov. 22	8.55	8.29	1	−0.26	–	–	–	–	–
23	–	–	–	–	–	8.47	1	8.44	½
26		–	–	–	–	8.47	1	–	–
27	8.43	8.62	1	+0.19	–	–	–	8.44	½
28	–	8.20	1	−0.22	–	–	–	–	–
29	–	8.40	1	−0.01	–	–	–	–	–
Dec. 1	–	8.38	1	−0.01		–	–	–	–
2	8.38	–	–	–	–	8.30	1	8.69	½
3	–	8.49	1	+0.11	–	–	–	–	–
4	–	8.49	1	+0.11	–	–	–	8.72	½
5	–	8.38	1	0.00	8.4	8.52	1	–	–
6		8.15	1	−0.23	8.2	–	–	–	–
7	8.38	–	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–	8.17	½
10	–	8.42	1	+0.02	–	–	–	–	–
12	8.12	–	–	–	–	–	–	–	–
13	–	8.49	1	+0.06	8.4	8.51	1	8.69	½
15	–	8.68	1	+0.24	–	–	–	–	–
17	8.48	8.49	1	+0.01	–	8.59	1	8.83	½
18	–	8.49	1	0.00	–	–	–	–	–
19	–	8.33	1	−0.16	–	–	–	–	–
20	–	–	–	–	9.1	8.67	1	–	–
22	8.54	8.52	1	−0.02	–	–	–	–	–
23	–	8.49	1	−0.06	–	–	–	–	–
25		8.68	1	+0.07	–	8.49	1.	–	–
27	8.65	8.63	1	−0.02	–	–	–	–	–
29	–	8.67	1	−0.03	–	8.65	1	–	–
30	.–	8.77	1	+0.04	–	–	–	–	–
1895	m	m	w	d	m	m	w	m	w
Jan. 1	8.78	8.69	1	−0.09	–	8.72	1	–	–
2	–	8.87	1	+0.05	9.0	–	–	–	–
3	–	–	–	–	–	8.77	1	–	–
4	–	–	–	–	–	–	–	8.72	½
6	8.96	–	–	–	–	–	–	–	–
7	–	–	–	–	–	8.64	1	8.71	½
11	9.16	–	–	–	–	–	–	–	–
14	–	9.44	½	+0.15	–	–	–	–	–
15	–	–	–	–	–	–	–	–	–
16	9.38	–	–	–	–	8.99	1	–	–
17	–	9.34	½	−0.08	–	–	–	–	–
20	–	9.34	1	−0.22	–	–	–	–	–
21	9.61	–	–	–	–	–	–	–	–
22	–	–	–	–	–	9.72	1	–	–
23	–	9.60	½	−0.11	–	–	–	–	–
24	–	9.80	1	+0.04	–	–	–	–	–
26	9.86	–	–	–	–	9.85	1	–	–
27	–	9.86	1	−0.05	–	–	–	–	–
28	–	–	–	–	–	–	–	10.31	¼
31	10.12	–	–	–	–	10.00	1	–	–
Feb. 1	–	–	–	–	–	–	–	10.31	½
5	10.41	–	–	–	10.2	–	–	–	–
7	–	–	–	–	–	–	–	10.42	¼
10	10.70	–	–	–	–	–	–	–	–
13	–	10.90	½	+0.03	–	–	–	–	–
15	–	–	–	–	–	11.09	½	–	–
21	–	–	–	–	–	11.10	½	–	–

The weighted mean of the departures from the plotted curve, as shown by the residuals in the column *d* is $0^{M}.089$; the probable error of a single observation of weight unity is $\pm 0^{M}.083$.

The entirely normal character of the observed light-curve is apparent upon inspection of Fig. 1 of the accompanying plate, where all these observations are plotted, and is confirmed in detail by the figure of the same curve published by J. A. Parkhurst in *Popular Astronomy*, Vol. II, p. 317, and as to general character by the observations of H. M. Parkhurst, already referred to.

Prof. Pickering's paper in the *Astrophysical Journal* contains, including his strictures on my own results, certain fallacies, unsupported assertions and unfounded assumptions, which in justice to myself cannot be passed by with a general notice, and I shall comment in detail on those referring to the light-curve.

On page 306 the statement is made that "while these photographs fail to show whether the light-curve is pointed or rounded at the exact time of maximum, they indicate that the curvature, if any, is inappreciable except within a few days of the maximum." This impression is in part due to the short scale of the time-coordinate in Prof. Pickering's graphic presentation of the observations in the plate accompanying his article.

This tends to mask the general form of curve indicated by the points as plotted, and also gives an appearance of accordance which is liable to mislead the uncritical eye, and which at once disappears when the relative length of the abscissas is increased.

On plotting the same observations on the same scale as my own, as shown in Fig. 1, and drawing a free curve to satisfy these values, I found it to resemble my own observed curve quite closely; and upon plotting them with my own in Fig. 1, allowing a constant correction of $-0^{M}.6$ (the mean difference between the photographic and my visual observations falling on the same dates), they with a single exception fall on or near the curve, so that the same ten observations which by Prof. Pickering's table of residuals show a probable error of $\pm 0^{M}.155$ give by comparison with the curve in Fig. 1, $\pm 0^{M}.162$. If we omit the observation of 1894 Dec. 20, which is discordant by both curves, the probable error is respectively $\pm 0^{M}.149$ and $\pm 0^{M}.124$, so that on the whole, the photographic observations are rather better represented by the visually observed curve than by the law assumed by Prof. Pickering.

The date of maximum deduced in this manner from the photographic measures is 1894 Dec. 7. To ensure a determination which should be free from any suspicion or possibility of bias, I plotted the same points on a blank piece of cross-section paper, and sent it without explanation of any sort to Mr. J. A. Parkhurst, requesting him to draw a curve

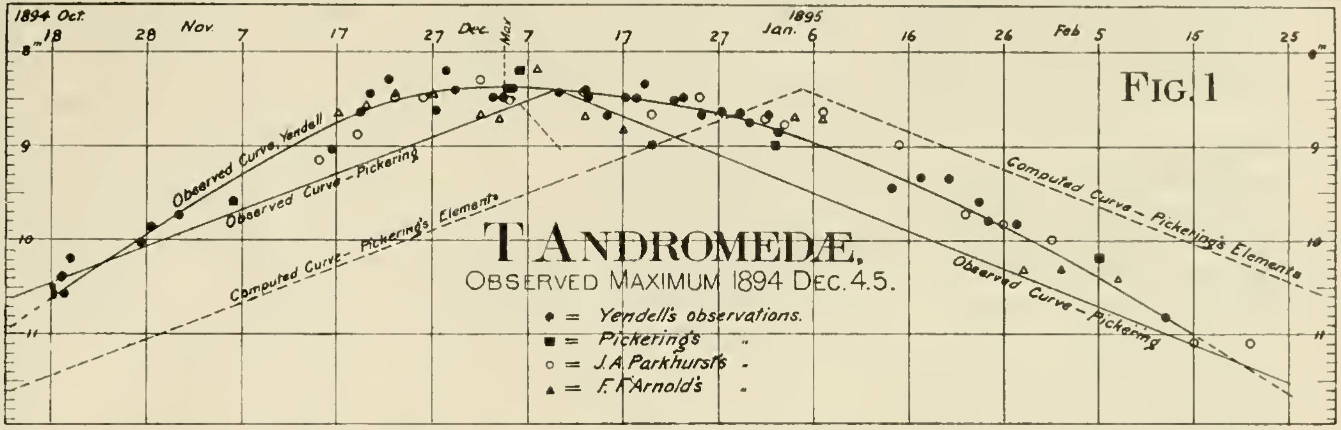

FIG. 1

T ANDROMEDÆ,
OBSERVED MAXIMUM 1894 DEC. 4.5.

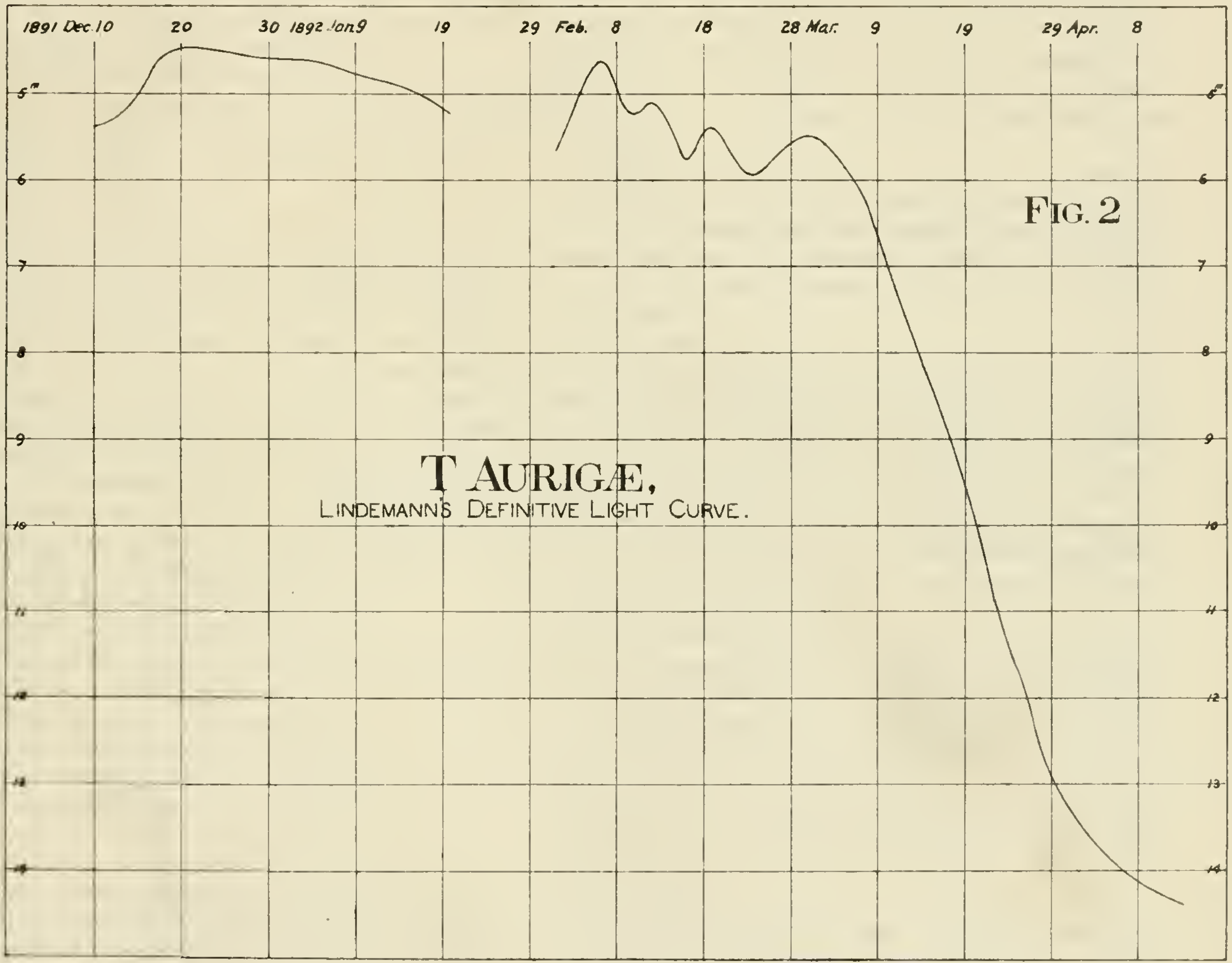

FIG. 2

T AURIGÆ,
LINDEMANN'S DEFINITIVE LIGHT CURVE.

to satisfy the points, and determine a maximum in the usual way, by drawing a diameter to the curve. Mr. PARKHURST's date of maximum obtained in this way is Dec. 8.

In view of the above facts, I feel justified in reiterating the assertion quoted by Prof. PICKERING from my former paper, that the form of curve assumed by him as representing the star's variation is not only inherently improbable, but has been proved by observation to be incorrect, departing widely from that observed, by two different methods of observation, by three competent observers.

On page 307 the statement is made that "the linear form is strikingly exemplified by Nova (*T*) *Aurigae* and other variables." The selection of *T Aurigae*, by Prof. PICKERING, as confirmatory of his assumed law, is unfortunate, for that star, in the first place, is distinctly of the class "nova," and its light-curve has all the irregularities characteristic of that class, as will be seen by a reference to Fig. 2 of the plate, which is a copy of LINDEMANN's definitive curve, as given by him in his monograph "*Die Lichtcurve des neuen Sterns von* 1892 (*T Aurigae*)," in the Bulletin of the Imperial Academy of Sciences of St. Petersburg, Vol. VII.

This curve shows no point of resemblance to that of Prof. PICKERING now under consideration, excepting its rapid linear decline. The entire dissimilarity of the general characters of the two curves will be at once evident upon comparison of the two figures.

T Andromedae, on the other hand, is as distinctly a star of the ordinary long-period type, of very regular variation, whose observed light-curve at the last maximum, resting as above remarked on the testimony of at least three competent observers, was entirely normal and regular; and I fail to find, among all the many variable stars the characteristics of whose changes are known to me, a single one whose behavior in any respect conforms to any law at all resembling that assumed by Prof. PICKERING in the present instance.

Further on the remark is made: "It may be noted, however, that unless he measured the variable photometrically, or used magnitudes photometrically determined for his comparison-stars, it would be impossible for him to tell whether the light-curve was linear or not," etc.

This is a bare assertion, unsupported by any pretence of proof, and strikes the writer as sweeping and unwarranted, brushing aside as it does by implication, as of no value, the whole fabric of the scale of star-magnitudes reared by the labor of all the observers, to whose work we owe at least ninety-nine one-hundredths of our knowledge on the subject. And it appears the more singular when the circumstances are taken into account, that in my series of observations, which is the one to which especial reference is had in the sentence quoted, the magnitude-estimates of the comparison-stars were made with great care, and with all the precautions suggested by the experience of eight years in this particular class of work; that the step-value shown by the process of comparison is a very normal one ($0^M.09$); and that the probable error of a single observation of full weight as compared with the light-curve most carefully and deliberately drawn from the whole series of thirty-eight observations is $\pm 0^M.08$, a value which compares favorably with those of the corresponding probable errors in the two Harvard Photometric Catalogues, $\pm 0^M.15$ and $\pm 0^M.20$ (see Potsdam Results, Vol. IX, p. 491).

So far as Prof. PICKERING is concerned, perhaps the best reply to the above-quoted assertion consists in calling attention to the circumstance that the magnitudes, so arrived at, correspond with remarkable closeness to the Harvard measures of magnitude during the same maximum, when the constant correction for the difference between the visual and photographic magnitudes is taken into account.

The reference to NEWTON's law of cooling seems rather gratuitous. That an incandescent mass, so large as to be visible to us at stellar distances should lose its light so rapidly from simple cooling as to become invisible, and then from some unknown cause be again heated to its former incandescence, and this not once only, but repeatedly and regularly at intervals of about nine months, is too severe a draft upon our conceptions of physical possibilities to be entertained.

We know nothing at all as to the causes of the variation of this class of stars; but we do know that, out of the many stars whose changes have been watched, there is up to the present time none whose behavior suggests any such law of variation as the one put forward by Prof. PICKERING in the present case.

There appears to be an impression existing among those not thoroughly conversant with the subject, that the old methods of determination of star-magnitudes, as compared with the modern photographic and photometric methods, are crude and inaccurate to a degree. This impression has been studiously fostered by such publications as the two articles on the photographic observations of *T Andromedae* which constitute the *raison d'être* of the present paper, and has gained considerable ground among those not actively interested in this class of work.

The impression is an entirely mistaken one. No form of photometer, except the wedge, has yet been devised which does not finally depend on the estimation by the human eye of the equality between two images. All who have tried such instruments, or who have had experience in direct comparisons of nearly equal stars, know the difficulty of pronouncing upon this point, which is far greater than that of estimating the value of small differences; and to this difficulty is due the greater part of the observational error in both methods.

The wedge-photometer has also its peculiar sources of error, and in point of general accuracy does not appear to surpass the various forms of two-image photometers.

With regard to the photographic method, for which especial precision has been claimed, — while it possesses an undoubted and incontestable advantage in the matter of the permanency of the record, its advantage appears to stop there. Those who know the numerous causes which must continually affect the uniformity of the star-images on the plate, and who are familiar with the microscopic characteristics of photographic images, find it exceedingly difficult to credit the claim that the impressions of stars, so faint as the eleventh magnitude and less, can be measured with a certainty sufficient for the attainment of such precision as is claimed for these measurements.

Upon examination, the estimates of stellar brightness by the Argelander method, when made by a practised eye, appear quite to hold their own in the matter of accuracy, if they do not surpass the other methods.

While preparing that part of this article which deals with the errors of observation, I was led to make estimates, in the same manner as in the case of *T Andromedae*, of the probable errors of some of the series of telescopic observations of long-period variables made by myself in 1893 and 1894.

The curves plotted for the original reductions were used for the purpose, and the results are so interesting that it seems not out of place to give them here as collateral testimony of the value of the Argelander method.

The results are as follows: the step-values in the column "step" are deduced from the light-scale, and the values in the column *r* are those found in each case for the probable error of a single observation of weight unity.

	Obs.	Step	*r*
		M	M
112 *R Andromedae.*	18	0.07	±0.079
1805 *V Orionis.*	22	0.10	0.051
4847 *S Virginis.*	21	0.12	0.059
5190 *R Camelopardalis.*	20	0.08	0.072
5950 *W Herculis.*	12	0.09	0.080
7085 *RT Cygni.*	15	0.13	0.090
7192 *Z Cygni.*	21	0.07	0.045
7458 *V Delphini.*	13	0.07	0.032
7560 *R Vulpeculae.*	14	0.09	0.031

It will be seen on examining this list that the accuracy of my *T Andromedae* series is by no means exceptional, and that when compared with the Harvard photographic observations, the eye-observations lose nothing by the comparison. Thus, for photometric measures, we have the Harvard Photometry and the Photometric revision of the *Durchmusterung*, with the respective probable errors of ±0M.15 and ±0M.20 (see Vol. IX of the Potsdam Publications, quoted above) and the Potsdam Photometric Durchmusterung, with ±0M.075.

If further evidence be needed of the sufficiency of the Argelander method, the discovery by Chandler, of the short-period variable *Y Aquilae*, with a range of only 0M.4, and its confirmation by myself, during the summer of 1894 may be cited as showing the power of the trained eye to distinguish small changes of light.

Dorchester, Mass.

NEW ASTRONOMICAL WORK.

Inventaire Général et Sommaire des Manuscrits de la Bibliothèque de l'Observatoire de Paris, par M. G. Bigourdan.

This publication, containing sixty pages, forms a part of volume XXI of the Memoirs of the Paris Observatory. It comprises a full catalogue of the manuscripts, with exact reference, for each, to the place in which it is deposited.

The records of observations of the Cassinis and Maraldis formed the nucleus of the collection: to these was subsequently added the extensive collection of J. N. Delisle, which contained copies of the observations of Tycho Brahe, Picard, LaHire, Hevelius, Gottfried Kirch, and others, as well as some of the originals: also important Chinese manuscripts upon astronomical and chronological subjects. Later yet, there were incorporated manuscripts from Lemonnier and others, copies of the observations of Lacaille, D'Agelet and others, and the original ones of the *Histoire Céleste*.

Upon the historical value of these manuscripts there is no occasion to comment, nor indeed is this the place. It suffices to mention, by way of illustration, that there are fifteen folio volumes of the correspondence of Hevelius, the letters received and the answers being autograph; likewise four folio volumes of his observations, written by his own hand, and extending from 1657 to 1679.

In preparing this valuable inventory, Mr. Bigourdan has much facilitated an important part of the labor of the historian of astronomy.

CONTENTS.

Observations of Small Planets, by Prof. Edgar Frisby.
Maxima and Minima of Variable Stars Observed in 1894–1895, by G. Gruss and V. Láska.
On the Light-Curve of 103 *T* Andromedae, by Mr. Paul S. Yendell.
New Astronomical Work.

Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed June 27.*

THE
ASTRONOMICAL JOURNAL.
No. 349.

VOL. XV. BOSTON, 1895 JULY 16. NO. 13

MICROMETRICAL MEASURES OF DOUBLE STARS, MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA, FROM 1895 APRIL 10 TO MAY 5,

By T. J. J. SEE.

While spending a short vacation at the University of Virginia, on leave of absence from the University of Chicago, I expressed to Professor STONE, Director of the Leander McCormick Observatory, my desire to secure a few measures of certain double stars whose orbits I am investigating. He very kindly placed the great refractor at my disposal during those hours of the night when he was not occupied with observations of the satellites of *Saturn*, and as a result of my efforts I have obtained the following micrometrical measures.

The observations were intentionally confined to a small list of well known stars, and as most of these are close and difficult objects, and the weather was rainy and changeable during a large part of the time, the number of measures is not so great as might have been secured, had I given my attention to a larger list including easier objects. Thus, although only a small number of stars were measured, every precaution was taken to secure accurate results, and I have reason to hope that these observations will be valuable in improving the elements of orbits which are now under revision.

Most of the observations were made with a power of 560; but a few of the closest objects required powers of 850 and 1300. The position-angle is usually the mean of four settings, and the distance that of three or four double-distances. In the last column are given the estimated distances, and a few remarks relative to the seeing. The approximate places of the stars are referred to the equator and mean equinox of 1900.0. My thanks are due to Professor STONE for the use of the great telescope, and for courtesies extended during my stay in Charlottesville.

η Cassiopeae = Σ60.

$\alpha = 0^h\ 43^m. \quad \delta = +57°\ 18'.$

t	θ_0	ρ_0	Remarks
	°	″	
1895.277	203.5	4.94	near the horizon
1895.294	203.7	4.80	
1895.310	202.9	4.77	seeing excellent
1895.294	203.4	4.84	

F.9 *Argus* = β 101.

$\alpha = 7^h\ 47^m. \quad \delta = -13°\ 32'.$

t	θ_0	ρ_0	Remarks
	°	″	
1895.294	287.3	0.56	est. $\rho = 0''.4 \pm$
1895.296	282.4	0.55	est. $\rho = 0''.5 \pm$
1895.302	281.6	0.62	good seeing
1895.297	283.8	0.58	

ζ Cancri = Σ1196.

$\alpha = 8^h\ 6^m. \quad \delta = 18°\ 0'.$

A AND B

	°	″	
1895.277	22.8	1.16	
1895.280	22.3	1.1 ±	hazy; bad seeing
1895.288	23.2	1.25	hazy
1895.294	23.1	1.01	good seeing
1895.285	22.8	1.13	

$\frac{\text{A B}}{2}$ AND C

	°	″	
1895.277	121.5	5.53	
1895.280	119.0	5.12	hazy
1895.288	121.1	5.46	hazy
1895.294	119.6	5.28	good seeing
1895.285	120.3	5.35	

Σ3121.

$\alpha = 9^h\ 11^m. \quad \delta = +29°\ 0'.$

	°	″	
1895.305	12.0	0.56	est. $\rho = 0''.5 \pm$
1895.310	13.2	0.56	est. $\rho = 0''.55 \pm$
1895.307	12.6	0.56	

ω Leonis = Σ1356.

$\alpha = 9^h\ 23^m. \quad \delta = +9°\ 30'.$

	°	″	
1895.274	106.2	0.90	good seeing
1895.277	105.3	0.90	est. $\rho = 0''.8 \pm$
1895.283	106.0	0.77	est. $\rho = 0''.85 \pm$
1895.278	105.8	0.86	

ξ Ursae Majoris = Σ1523.

$\alpha = 11^h\ 13^m. \quad \delta = +32°\ 7'.$

	°	″	
1895.310	175.5	1.94	good seeing
1895.339	176.2	2.03	good seeing
1895.340	178.2	1.89	images good
1895.330	176.6	1.95	

γ *Virginis* = Σ1670.

$\alpha = 12^h\ 37^m$. $\delta = -0^\circ\ 53'$.

t	$\theta_\circ$	$\rho_{''}$	Remarks
	°	″	
1895.274	330.4	5.66	unsteady
1895.277	331.6	5.95	images blazing
1895.283	331.1	5.71	
1895.302	331.3	5.87	seeing excellent
1895.343	330.9	5.82	good seeing
1895.296	331.1	5.80	

F. 12 *Comae Berenices* = Σ1728.

$\alpha = 13^h\ 5^m$. $\delta = +18^\circ\ 4'$.

	°	″	
1895.277	single with powers up to 1300		unsteady
1895.283	17.9	0.16	est. $\rho = 0''.15 \pm$: elongated
1895.296	11.9	0.11	est. $\rho = 0''.18 \pm$; g. seeing
1895.299	11.9	0.15 ±	bad seeing
1895.293	13.9	0.14	

F. 25 *Canum Venaticorum* = Σ1768.

$\alpha = 13^h\ 33^m$. $\delta = +36^\circ\ 48'$.

		″	
1895.274	136.5	1.02	
1895.277	135.5	1.24	est. $\rho = 1''.10 \pm$
1895.283	(141.1)	1.09	angle reading doubtful
1895.296	137.3	0.91	est. $\rho = 1''.1 \pm$
1895.282	136.4	1.06	

OΣ285.

$\alpha = 14^h\ 42^m$. $\delta = +42^\circ\ 49'$.

	°	″	
1895.305	146.7	0.35 ±	elongated
1895.310	147.9	0.33	est. $\rho = 0''.35 \pm$
1895.340	147.4	0.22	separated ; est. $\rho = 0''.38 \pm$
1895.318	147.3	0.30	

η *Coronae Borealis* = Σ1937.

$\alpha = 15^h\ 19^m$. $\delta = +30^\circ\ 38'$.

	°	″	
1895.299	286.0	0.43	est. $\rho = 0''.5 \pm$
1895.302	284.1	0.50	est. $\rho = 0''.4 \pm$
1895.305	285.0	0.43	est. $\rho = 0''.55 \pm$
1895.302	285.0	0.45	

μ^2 *Bootis* = Σ1938.

$\alpha = 15^h\ 21^m$. $\delta = +37^\circ\ 41'$.

	°	″	
1895.299	82.5	0.75	well separated
1895.302	82.4	0.85	images good
1895.340	85.5	0.92	est. $\rho = 0''.85 \pm$
1895.314	83.5	0.84	

γ *Coronae Borealis* = Σ1967.

$\alpha = 15^h\ 39^m$. $\delta = +26^\circ\ 37'$.

	°	″	
1895.299	112.7	0.62	
1895.302	116.8	0.65	est. $\rho = 0''.75 \pm$
1895.305	115.0	0.73	est. $\rho = 0''.7$
1895.302	114.8	0.67	

University of Virginia, 1895 *May* 8.

ξ *Scorpii* = Σ1998.

$\alpha = 15^h\ 59^m$. $\delta = -11^\circ\ 5'$.

A AND B

t	$\theta_\circ$	ρ_0	Remarks
		″	
1895.274	209.9	1.04	est. $\rho = 0''.80 \pm$: blurred
1895.310	207.7	1.02	unsteady
1895.340	213.3	1.05	images good
1895.308	210.3	1.04	

$\frac{AB}{2}$ AND C

	°	″	
1895.274	61.4	7.42	blurred
1895.310	63.3	7.40	unsteady.
1895.340	64.4	7.39	images good
1895.308	63.0	7.40	

ζ *Herculis* = Σ2084.

$\alpha = 16^h\ 37^m$. $\delta = +31^\circ\ 47'$.

	°	″	
1895.299	35.8	1.16	est. $\rho = 1''.0 \pm$
1895.339	38.2	1.10	images good
1895.340	36.2	1.27	well defined.
1895.326	36.7	1.18	

Σ2173.

$\alpha = 17^h\ 25^m$. $\delta = -0^\circ\ 59'$.

	°	″	
1895.283	336.3	1.17	est. $\rho = 1''.05 \pm$
1895.294	338.4	1.19	est. $\rho = 1''.1 \pm$
1895.340	337.2	1.22	good seeing
1895.306	337.3	1.19	

μ' *Herculis* = Σ2220.

$\alpha = 17^h\ 43^m$. $\delta = +27^\circ\ 47'$.

	°	″	
1895.340	41.2	0.86	exeessively faint ; blue
1895.342	37.4	0.75 ±	clouds
1895.343	38.8	0.78 ±	clouds
1895.342	39.1	0.80	

F. 70 *Ophiuchi* = Σ2272.

$\alpha = 18^h\ 0^m$. $\delta = +2^\circ\ 33'$.

	°	″	
1895.277	298.1	2.04	daylight ; unsteady
1895.339	298.6	2.34	good seeing
1895.340	299.2	2.29	images good
1895.317	298.6	2.22	

F. 99 *Herculis* = A.C.15.

$\alpha = 18^h\ 3^m$. $\delta = +30^\circ\ 33'$.

		″	
1895.299	307.0	0.84	est. $\rho = 0.8 \pm$

ζ *Sagittarii.*

$\alpha = 18^h\ 56^m$. $\delta = -30^\circ\ 2'$.

	°	″	
1895.299	200.7	0.31	elong.. blur. est. $\rho = 0''.3 \pm$
1895.339	190.1	0.42	elong.. est. $\rho = 0''.4 \pm$
1895.340	193.0	0.34	clear elong., est. $\rho = 0''.33 \pm$
1895.326	191.7	0.36	

β *Delphini* = β151.

$\alpha = 20^h\ 33^m$. $\delta = +14^\circ\ 15'$.

	°		
1895.310	351.8	0.49	est. $\rho = 0''.42$. good seeing.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE WESLEYAN UNIVERSITY OBSERVATORY, MIDDLETOWN, CONN., WITH 12-INCH REFRACTOR,

BY W. S. EICHELBERGER.

1895 Greenwich M.T.	*	No. comp.	Planet — * Δα	Planet — * Δδ	Planet's apparent α	Planet's apparent δ	log pΔ for α	log pΔ for δ
			(130).					
Feb. 13 15h 0m 48s	1	10 , 5	s −11.66	′ ″ +5 16.3	h m s 10 4 46.5	° ′ +12 50.3	n9.410	0.630
20 16 10 6	2	10	+33.84	. . .	9 58 33.37	. . .	n8.850	. . .
			(287).					
Feb. 20 17 26 20	3	10 , 5	+41.95	+2 46.7	10 33 39.87	+12 54 3.9	7.958	0.629

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	h m s 10 4 26.1	s +2.02	° ′ ″ +12 45.0	″ −5.9	DM. 12°2156
2	9 57 57.41	+2.42	+13 58 33.5	−5.8	Schjellerup 3693
3	10 33 52.83	+2.09	+12 51 25.3	−8.1	Schjellerup 3894

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

BY J. A. PARKHURST.

103. *T Andromedae.*

I have 21 observations between 1894 Nov. 15 and 1895 March 1. The star rose rapidly from $8^{M}.3$ to a maximum $7^{M}.6$, 1894 Dec. 3. The decline was less rapid, but quite steady. The magnitude at the last observation was 10.5.

814. *S Persei.*

This star has been watched since 1892 Nov. 18. Since that date 48 observations yield a minimum $11^{M}.0$, 1893 April 25, and a maximum $8^{M}.6$, 1894 May 1.

906. *R Trianguli.*

When first observed, 1894 Nov. 20, this star was $10^{M}.0$. It rose very rapidly to a maximum $6^{M}.6$, 1895 Feb. 23, after which it fell more slowly, till at the last observation, March 27, it was $7^{M}.4$. I have 20 observations between the above dates.

1623. *T Camelopardalis.*

From 1894 Nov. 15 to 1895 March 2, I have 21 observations. The star rose steadily from $8^{M}.4$ to a maximum $7^{M}.0$, 1895 Jan. 8. The decline was a little more rapid, with some fluctuations. When last observed it was $8^{M}.6$.

1805. *V Orionis.*

I began this season's observations 1894 Nov. 26, when the star was $9^{M}.5$. It fell steadily till it passed below the limit of my 6.2-inch reflector, being last seen 1895 Jan. 26, when it was estimated $12^{M}.8$. It was seen as a glimpse-star by Mr. W. DEARDEN, at Trinidad, Colo., with a 9-inch reflector, during February and March, being more easily seen than 2815 *U Geminorum* at minimum. After it began to rise, I first glimpsed it March 26, and found it 12^{M} April 11. At the last observation, April 18, it was $10^{M}.5$ or 11^{M}. A minimum $<13^{M}$ is suggested for March 1 ±10^{d}.

2100. *U Orionis.*

I have 17 observations, between 1894 Nov. 26 and 1895 April 3, yielding a maximum $6^{M}.0$ 1895 Feb. 22. At the first observation the magnitude was $11^{M}.6$; at the last it was $7^{M}.0$.

2815. *U Geminorum.*

On 1895 March 4 this star was invisible, my limit being $<12^{M}$. The ensuing observations are as follows, the time being Greenwich mean.

	M		M
1895 Mar. 7.54	9.6	1895 Mar. 13.58	9.4
8.54	9.5	16.58	10.3
9.56	9.2	17.58	10.9
10.63	9.6	18.58	11.9
11.54	9.2		

The bright moonlight up to March 11 made the estimates somewhat discordant, but the resulting maximum March $11^{d}.2$ is probably near the truth.

7085. *RT Cygni.*

This star rose rapidly from $10^{M}.1$, 1894 Nov. 15, to a maximum $7^{M}.0$, Dec. 21, then fell more slowly to $8^{M}.8$, 1895 Feb. 1, the time of the last observation. I have 17 observations between the above dates.

8321. *V Cassiopeae.*

I have 28 observations of this star between 1894 Nov. 15 and 1895 April 17. It fell from $11^{\rm M}.3$ at the first observation to a minimum $12^{\rm M}.3$, 1894 Nov. 24, then rose steadily and rapidly to a maximum $8^{\rm M}.0$, 1895 March 5, then fell to $9^{\rm M}.2$ at the last observation. I have observed two maxima and two minima of this star. The period derived from the minima is $248^{\rm d}$, from the maxima $223^{\rm d}$; the interval $M-m$ being $116^{\rm d}$ and $101^{\rm d}$.

Marengo, Ill., 1895 *April* 29.

OBSERVATIONS OF *NOVA* (5533 *R*) *NORMAE*,

BY W. W. CAMPBELL.

The new star announced by the Harvard College Observatory, in the constellation *Norma*, has now become very faint. Its altitude when on the meridian of Mt. Hamilton, is only $2\frac{1}{2}$ degrees. It is near the limit of vision in the 36-inch telescope, owing to the strong atmospheric absorption, and to the constant unsteadiness of the image. I have, therefore, brought together my observations of the magnitude of the *Nova*.

1894 Feb. 13. The quantity of light in the new star is estimated to be $\frac{1}{4}$ or $\frac{1}{5}$ that of the $8^{\rm M}$ star, Arg. Gen. Catal. 20940.

Feb. 28	The	new	star	equals	$\frac{1}{5}$	of	no.	20940
Mar. 2	"	"	"	"	$\frac{1}{5}$	"	"	"
Mar. 6	"	"	"	"	$\frac{1}{6}$	"	"	"
Apr. 5	"	"	"	"	$\frac{1}{6}$	"	"	"
May 2	"	"	"	"	$\frac{1}{8}$	"	"	"
May 8	"	"	"	"	$\frac{1}{8}$	"	"	"

and $\frac{1}{4}$ of the $8\frac{3}{4}^{\rm M}$ star, Arg. Gen. Catal. 20926.

1895 Feb. 26. The quantity of light in the *Nova* is from $\frac{1}{50}$ to $\frac{1}{100}$ that of Arg. Gen. Catal. 20940.

May 23. The *Nova* is nearly on the limit of vision, seeing fair; its light estimated roughly as $\frac{1}{100}$ that of no. 20940.

From the foregoing observations we have the following magnitudes of the *Nova*:

	M		M
1894 Feb. 13	9.6	1894 May 2	$10\frac{1}{4}$
Feb. 28	9.8	May 8	$10\frac{1}{4}$
Mar. 2	9.8	1895 Feb. 26	$12\frac{1}{2}$
Mar. 6	10	May 23	13
Apr. 5	10		

The star's spectrum could not be seen on the two dates in 1895. It may be nebular as in 1894, or it may be continuous.

OBSERVATIONS OF *NOVA* (7787 *Q*) *CYGNI*,

BY W. W. CAMPBELL.

A few observations of the new star of 1876 have been secured.

1894 April 5. The star is midway in brightness between Dr. COPELAND's comparison-stars, no. 50, mag. 15, and no. 51, mag. 14.3. The *Nova* is therefore about $14^{\rm M}.7$.

1894 May 8. The *Nova* is slightly fainter than Dr. COPELAND's comparison-star, no. 49, mag. 14.7, and brighter than no. 50, mag. 15. It is therefore about $14^{\rm M}.8$.

1895 May 23. The magnitude remains unchanged at about 14.8. The *Nova's* spectrum, viewed through a direct-vision Browning spectroscope, appears to be continuous.

OBSERVATIONS OF SOUTHERN VARIABLE STARS,

BY ALEXANDER WILLIAM ROBERTS.

Southern Long-Period Variables.

The following list contains those Harvard stars that have been watched here through their extreme limits.

Several of the other long-period variables, announced by Prof. PICKERING, indicate variation, but in their cases it has been thought better to wait until at least one maximum and one minimum phase have been observed, before announcing confirmation.

	Star	R.A. (1900)	Decl.	Limits
		h m	° ′	M M
*(1)	— *Sculptoris*	0 10.4	−32 36	6.5 − < 9.5
(2)	— *Horologii*	2 49.5	−50 10	5.8 − 10.0
*(3)	— *Caeli*	1 37.1	−38 26	7.5 − 10.0
(4)	— *Centauri*	13 36.0	−33 6	6.5 − <10.0
(5)	— *Scorpii*	16 50.3	−30 26	6.8 − 9.3
*(6)	— *Pavonis*	18 3.3	−63 38	7.5 − 9.8

No. 2 is distinctly visible to the naked eye at maximum, and as two maxima and one minimum have been observed here, its variation is certain. [Ch. 1018, *R Horologii*. — ED.]

No. 4 is the star recently announced as a new variable by Lieut. Col. MARKWICK. I may be allowed to state, without raising in any way the question of the discovery of the star, that five months before Prof. PICKERING's notice in no. 3269 of the *Astr. Nachr.*, Col. MARKWICK wrote me as to its variation, and asked me to confirm his conclusions as early as possible. I was able to secure only three or four measures, when I was obliged to give up observing for nearly a couple of months. By the time I was well enough to resume regular observations, the star was too low down. Its period is not far from that found by Col. MARKWICK. [Ch. 4896, *T Centauri*. — ED.]

* Nos. (1), (3), (6) are *S Sculptoris*, *R Caeli*, *R Pavonis*, respectively. See *A.J.* no. 347. — ED.

No. 5 has already been confirmed by Yendell. Its maximum limits are certainly higher than that given in Chandler's catalogue ($7^{M}.3$ to $7^{M}.7$); for at its last maximum phase, I was able, but that was all, to see it. Now $6^{M}.8$ to $7^{M}.0$ is my limit for unaided vision. [Ch. 6062, *RR Scorpii.* — Ed.]

Variation of Lac. 7646, [*Ch.* 6546 *RS Sagittarii.*]

Lac. 7646, Chandler No. (6546), is an *Algol*-variable with a period of 2 days, 9 hours, 59.1 minutes.

It was suspected of variation by Dr. Gould in 1872; the note in the *Uranometria Argentina* (p. 288), reading as follows:

"The estimates for this star vary from $6^{M}.2$ to $7^{M}.4$. Comparisons were made by Mr. Davis in 1871 from August 21 to November 6; and in 1872 from July 25 to September 8. The result of these comparisons is perplexing in the extreme, nor are they apparently reconcilable, except upon the supposition that a large proportion of the comparison-stars are also variable. . . . . The indications are that the star fulfils its period in about 58 hours, the minimum preceding the maximum by not more than a quarter of the period. Yet the great changes in the relative brightness of the other stars render it uncertain how far their variation may have affected this inference, deduced from sequences alone."

The type of variation was suspected here last year, but a sharp attack of influenza prevented my obtaining observations at all points of its period. During April and May this year, the star was systematically observed and measures secured all along the light-curve.

The following are the chief features and elements of its variation, which consists of two minimum phases, one twice as long as the other, and more decidedly marked.

Total period,	$2^{d}\ 9^{h}\ 59^{m}.1$
Duration of constant period,	39 hours
Duration of chief minimum phase,	12 hours
Duration of secondary minimum phase,	7 hours
Magnitude at constant period,	6.60
Magnitude at chief minimum,	7.65
Magnitude at secondary minimum,	7.00
Epoch of chief min. phase,	1895 May 25, $8^{h}\ 6^{m}$ (G.M.T.)
Epoch of secondary min. phase,	" May 26, $13^{h}\ 1^{m}$

The curve is symmetrical on each side of the two minima, an expression of the form

$$(m-M) \;=\; xt + yt^2 + zt^3$$

satisfying the observations at minima.

I purpose dealing with this later on, when I hope to obtain some of the orbital elements from the observations.

NEW ELEMENTS OF THE ORBIT OF Σ3121,

By T. J. J. SEE.

This double star was discovered in 1831 by William Struve, who rated the magnitudes of the components at 7.5 and 7.8 respectively. Observations of this pair, recently made with the 26-inch refractor of the Leander McCormick Observatory of the University of Virginia, convince the writer that the brightness of the components has been overestimated by at least a whole magnitude. The star is close and very faint, and the natural difficulty of the object will doubtless account for the rather large discordances in some of the observations.

As Σ3121 has been observed for many years, and the pair has a rapid orbital motion, several orbits have been published by previous investigators. The following is believed to be a complete list of the elements hitherto published:

P	T	e	a	Ω	i	λ	Authority	Source
yrs.			″	°	°	°		
39.18	1850.0	0.3471	0.696	19.94	52.4	143.3	Fritsche, 1866	Bulletin de l'Acad. de St. Pétersbourg, t. X
40.62	1850.0	0.3725	0.715	23.5	54.11	141.6	Fritsche, 1866	
37.03	1842.78	0.26	0.71	16.0	74.25	149.5	Doberck, 1877	*A.N.* 2156
34.642	1878.52	0.3086	0.6725	24.85	75.43	129.45	Celoria, 1887	*A.N.* 2808

From an investigation of all the observations I find the following elements:

$$P = 34.00 \text{ years}$$
$$T = 1878.30$$
$$e = 0.330$$
$$a = 0''.6692$$
$$\Omega = 28^\circ.25$$
$$i = 75^\circ.00$$
$$\lambda = 127^\circ.52$$
$$n = +10^\circ.5883$$

Apparent orbit:

Length of major axis	= $1''.318$
Length of minor axis	= $0''.349$
Angle of major axis	= $27^\circ.4$
Angle of periastron	= $189^\circ.6$
Distance of star from center	= $0''.142$

The following is a comparison of the computed and observed places:

COMPUTED AND OBSERVED PLACES.

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
	°		″	″		″		
1832.31	20.0	22.3	0.85	0.79	— 2.3	+0.08	3	W. Struve
1840.31	66.5	17.3	0.40 ±	0.35	+19.2	+0.05	3–1	O. Struve
1844.28	193.5	189.8	0.33	0.29	+ 3.7	+0.04	2–1	O. Struve
1846.29	207.6	205.2	0.55	0.48	+ 2.4	+0.07	1	O. Struve
1847.34	214.2	210.1	0.54	0.52	+ 4.1	+0.02	1	O. Struve
1848.25	213.0	214.1	0.53	0.52	— 1.1	+0.01	1	O. Struve
1849.32	223.3	218.8	0.48	0.50	+ 5.5	—0.02	1	O. Struve
1850.30	228.6	223.9	0.42	0.45	+ 4.7	—0.03	1	O. Struve
1851.26	239.7	230.1	0.33	0.39	+ 9.6	—0.06	1	O. Struve
1861.26	8.9	9.9	0.67	0.58	— 1.0	+0.09	1	O. Struve
1863.11	14.8	14.6	0.7	0.66	+ 0.2	+0.04	1	Dembowski
1864.30	13.0	18.1	0.71	0.73	— 5.1	—0.02	1	O. Struve
1865.77	26.8	21.3	0.80	0.78	+ 5.5	+0.02	2	Engelmann
1867.65	21.3	24.8	0.70	0.79	— 3.5	—0.09	5	Dembowski
1868.30	27.6	26.2	0.81	0.79	+ 1.4	+0.02	2	O. Struve
1869.31	26.1	28.2	0.88	0.76	— 2.1	+0.12	1	O. Struve
1870.38	28.6	30.6	0.57	0.71	— 2.0	—0.14	3	Dunér, 2; Gl., 1
1871.30	31.8	32.8	0.65	0.65	— 1.0	0.00	11	Gl., 1; Dunér, 3; OΣ. 2; Dembowski, 5
1872.20	36.4	35.6	0.68	0.58	+ 0.8	+0.10	1–2	OΣ, 1; Dunér, 0–1
1873.70	34.3	42.8	0.5 ±	0.42	— 8.5	+0.08	9–1	Dembowski, 8–0; Gl., 1
1874.28	46.7	46.7	0.53	0.36	0.0	+0.17	2	O. Struve
1875.27	63.0	63.0	0.25	0.22	0.0	+0.03	8–5	Dun., 1; OΣ., 1; Schiaparelli, 4; Dembowski, 2
1878.21	185.2	188.4	0.25	0.28	— 3.2	—0.03	1	Burnham
1879.57	200.4	200.2	0.43	0.41	+ 0.2	+0.02	5	Schiaparelli
1880.28	200.0	205.1	0.43	0.48	— 5.1	—0.05	4	Hall, 3; β. 1
1881.34	205.3	210.1	0.46	0.52	— 4.8	—0.06	2	Schiaparelli
1882.28	205.8	214.1	0.45	0.52	— 8.3	—0.07	4	Schiaparelli
1883.27	221.2	218.3	0.45	0.50	+ 2.9	—0.05	6–12	Engelmann, 6; Schiaparelli, 0–3; Hall, 0–3
1884.39	222.7	224.5	0.38	0.44	— 1.8	—0.06	4	Schiaparelli
1885.30	215.8	230.5	0.4 ±	0.39	—14.7	+0.01	3	Schiaparelli
1886.33	221.2	239.9	0.27	0.32	—17.7	—0.05	4	Engelmann
1887.27	250.4	252.5	0.22	0.27	— 2.1	—0.05	9	Schiaparelli
1888.27	286.3	272.6	0.22 ±	0.22	+13.7	0.00	7	Schiaparelli
1889.30	312.3	299.7	0.23 ±	0.21	+12.6	+0.02	7	Schiaparelli
1890.29	332.9	323.5	0.27 ±	0.24	+ 8.4	+0.03	4	Schiaparelli
1891.29	343.3	340.8	0.34	0.30	+ 4.2	+0.04	6	Hall, 4; Schiaparelli, 2
1892.26	355.3	354.0	0.41 ±	0.37	+ 1.3	+0.04	7	Schiaparelli
1893.25	2.3	359.7	0.47	0.43	+ 2.6	+0.04	7–2	Schiaparelli
1894.21	1.6	5.0	0.47	0.50	— 0.4	—0.03	4	Wilson, 1; Comstock, 3
1895.31	12.6	9.7	0.55	0.58	+ 2.9	—0.03	3	See

Some of the observations are vitiated by sensible systematic errors, so that occasionally our best observers differ by as much as 12°; and in succeeding years the angles are made to retrograde where they ought to be steadily advancing. Under these circumstances the residuals may be considered small, and the elements very satisfactory for so close and difficult a star. In following this star, observers should take every precaution against systematic error, since the orbit is highly inclined, and a small error in angle greatly affects the distance. Good observations are essential for any further improvement of the elements. A short ephemeris is:

t	θ_c	ρ_c
	°	″
1896.30	13.5	0.64
1897.30	16.2	0.69
1898.30	18.5	0.74
1899.30	20.7	0.77
1900.30	22.7	0.79

Since the companion is now approaching its maximum distance, the star will be relatively easy for a number of years.

The University of Chicago, 1895 *June* 1.

OBSERVATIONS OF ENCKE'S COMET,

MADE AT SMITH COLLEGE OBSERVATORY, NORTHAMPTON, MASS., WITH THE 11-INCH REFRACTOR AND FILAR-MICROMETER,

BY MARY E. BYRD.

1894–5 Greenwich M.T.		*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Dec. 20	13 26 44	1	11 , 5	−2 26.19	−3 19.6	22 16 36.23	+4 28 23.3	9.597	0.755
22	13 24 35	2	12 , 7	−4 0.39	+1 27.2	22 16 9.36	+4 11 16.4	9.602	0.757
27	13 2 42	3	12 , 6	+1 31.81	+1 13.6	22 15 3.74	+3 38 15.9	9.601	0.759
29	12 45 21	4	8 , 6	−3 34.63	+3 55.7	22 11 35.13	+3 23 17.9	9.593	0.759
31	12 44 7	5	12 , 6	−1 40.51	−2 8.3	22 14 1.37	+3 7 8.7	9.599	0.761
Jan. 1	12 27 13	6	12 , 8	−1 30.40	−1 15.2	22 13 42.29	+2 58 50.5	9.587	0.760
4	12 32 29	7	12 , 10	+0 55.99	−0 12.6	22 12 30.08	+2 30 34.6	9.604	0.764
12	12 27 28	8	8 , 5	−1 14.56	+1 9.1	22 6 8.14	+0 41 6.6	9.625	0.771
17	11 52 12	9	8 , 7	−3 44.25	−1 22.4	21 57 42.43	−1 17 1.1	9.621	0.776
19	11 15 58	10	11 , 6	−0 6.69	−2 13.5	21 52 46.29	−2 22 2.3	9.606	0.765

Mean Places for 1894.0 and 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 19 0.3	+2.39	+4 31 27.1	+15.8	Boss A.G. 7761
2	22 20 7.37	+2.38	+4 12 33.5	+15.7	Boss A.G. 7767
3	22 13 29.60	+2.33	+3 36 47.6	+14.7	Boss A.G. 7746
4	22 18 7.40	+2.36	+3 19 7.4	+14.8	Boss A.G. 7760
5	22 15 39.58	+2.33	+3 9 2.7	+14.3	Boss A.G. 7752
6	22 15 13.41	−0.72	+3 0 9.9	− 3.9	Boss A.G. 7751
7	22 11 34.85	−0.76	+2 30 51.7	− 4.5	Boss A.G. 7743
8	22 7 23.47	−0.77	+0 40 3.1	− 5.6	Schjellerup 9068, 9
9	22 1 27.47	−0.79	−1 15 32.0	− 6.7	Schjellerup 9021, 2
10	21 52 53.79	−0.81	−2 19 41.5	− 7.3	Munich (1) 29941, Munich (2) 12147

COMPARISON WITH EPHEMERIS IN *A.N.* 3263 (O—C).

	$\Delta\alpha$	$\Delta\delta$		$\Delta\alpha$	$\Delta\delta$
	s	″		s	″
1894 Dec. 20	−1.27	−5.3	1895 Jan. 1	+1.43	+ 3.8
22	+0.12	+3.0	4	+1.54	− 1.0
27	+0.93	−5.1	12	+2.94	+30.7
29	+1.62	+1.4	17	+4.73	+39.2
31	+1.37	−3.2	19	+4.94	+30.9

OBSERVATIONS OF *X HYDRAE*,

BY H. M. PAUL.

My observations of *X Hydrae* (the new variable announced by Mr. SKINNER in *A.J.* XIV, 160, and confirmed by Mr. PARKHURST in *A.J.* XV, 32) include 31 nights during the interval 2413154–3362 [1894 Nov. 21–95 June 17.] Plotting them gives the following:

			M
Min. at	2413205	[1895 Jan. 11]	11.8
Max. at	2413350 – 60	[1895 June 5–15]	8.4

The minimum is fairly accurate both as to time and magnitude, but the time of the maximum is very uncertain, as the star varied very little in the interval 1895 June 1–17 [6 observations] and no certain falling off in the light could be determined. All these last 6 observations were in moonlight or twilight and very near the horizon, and the magnitude 8.4 is probably one or two-tenths too bright, on account of the redness of the star. Even supposing it so much as half a magnitude too bright from this cause, the star reached a brightness at this maximum considerably exceeding that of any of the previous observations upon which rested my approximate elements, published in the first announcement [*A.J.* XIV, 160].

These elements would indicate a date of maximum a few days later than that given above, but there are not sufficient data for changing them till a maximum can be accurately determined next spring.

Washington, 1895 *June* 21.

EPHEMERIS OF VARIABLES OF THE *ALGOL*-TYPE,

Greenwich Mean Time,

BY PAUL S. YENDELL.

August			August			August			September			September		
1	*Z* Herculis	16	14	*U* Ophiuchi	17	27	*U* Ophiuchi	7	7	*Y* Cygni	17	20	*Z* Herculis	15
2	*Y* Cygni	18		*Y* Cygni	18		δ Librae	14	8	*Z* Herculis	16		*U* Ophiuchi	15
3	*U* Cephei	13	15	Algol	12		*Z* Herculis	16	9	*U* Ophiuchi	17	21	*U* Ophiuchi	11
	U Coronae	15		*U* Ophiuchi	13		*U* Coronae	19	10	*U* Ophiuchi	13		λ Tauri	14
	Z Herculis	17		*Z* Herculis	17	28	*U* Cephei	11		δ Librae	13		Algol	19
	U Ophiuchi	19	16	*U* Ophiuchi	10	29	*Z* Herculis	15		*U* Coronae	14	22	*U* Ophiuchi	7
4	δ Librae	7	17	*U* Coronae	10		*Y* Cygni	17		*Z* Herculis	14		*U* Cephei	9
	U Ophiuchi	16		*Z* Herculis	15		Algol	20		*Y* Cygni	17		*Z* Herculis	14
5	*U* Ophiuchi	12		*Y* Cygni	18	30	*U* Ophiuchi	15	11	*U* Ophiuchi	9		*Y* Cygni	16
	Z Herculis	16	18	Algol	9	31	*U* Ophiuchi	12	12	*U* Cephei	10	21	*U* Coronae	10
	Y Cygni	18		*U* Cephei	12		*Z* Herculis	16		*Z* Herculis	15		δ Librae	12
6	δ Librae	15	19	*Z* Herculis	17	September			13	*Y* Cygni	17		Algol	15
7	*Z* Herculis	17		*U* Ophiuchi	18	1	*Y* Cygni	17		λ Tauri	17		*Z* Herculis	15
8	*U* Cephei	12	20	*U* Ophiuchi	14		*U* Ophiuchi	8	14	*Z* Herculis	14		*U* Cephei	21
	Y Cygni	18		δ Librae	14		Algol	17		*U* Cephei	22	25	λ Tauri	13
	U Ophiuchi	20		*Y* Cygni	18	2	*U* Cephei	11	15	*U* Ophiuchi	14		*U* Ophiuchi	16
9	*U* Ophiuchi	16		*U* Coronae	21		*Z* Herculis	15	16	*Z* Herculis	15		*Y* Cygni	16
	Z Herculis	16	21	*U* Ophiuchi	11	3	δ Librae	13		*U* Ophiuchi	10	26	*U* Ophiuchi	12
	Algol	18		*Z* Herculis	15		*U* Coronae	16		*Y* Cygni	17		*Z* Herculis	14
10	*U* Ophiuchi	12	23	*U* Cephei	11	4	Algol	14		*S* Cancri	22	27	*U* Cephei	9
	U Coronae	13		*Z* Herculis	16		*U* Ophiuchi	16	17	*U* Cephei	10		*U* Ophiuchi	8
11	*U* Ophiuchi	9		*Y* Cygni	17		*Z* Herculis	16		*U* Coronae	12		Algol	12
	Z Herculis	17	24	*U* Coronae	8		*Y* Cygni	17		δ Librae	12	28	*Z* Herculis	15
	Y Cygni	18		*U* Ophiuchi	18	5	*U* Ophiuchi	12		λ Tauri	15		*Y* Cygni	16
12	Algol	15	25	*Z* Herculis	15	6	*U* Ophiuchi	8	18	*Z* Herculis	14	29	*U* Cephei	21
13	*U* Cephei	12		*U* Ophiuchi	15		*Z* Herculis	14		Algol	22		λ Tauri	12
	δ Librae	14	26	*U* Ophiuchi	11	7	*U* Cephei	10	19	*Y* Cygni	17	30	*Z* Herculis	13
	Z Herculis	16		*Y* Cygni	17		Algol	11		*U* Cephei	21		Algol	9

NOTE RELATIVE TO THE RUTHERFURD-DAVIS PARALLAX OF η *CASSIOPEAE*.

BY HERMAN S. DAVIS.

In *A.J.* 344, and also in Annals New York Academy of Sciences, Vol. VIII, p. 304, I have published my results of an investigation of the parallax of η *Cassiopeae*, from Rutherfurd photographic plates as

+0″.443 ±0″.043
or +0″.465 ±0″.044

according as obtained from three pairs and six pairs respectively. If, however, the probable errors had been computed after the method given in my *Declinations and Proper Motions of Fifty-six Stars*—Memoir I, New York Academy of Sciences, page 12, as suggested by Professor SAFFORD, the final values should have been given as

+0″.443 ±0″.038
or +0″.465 ±0″.034 respectively.

It is also interesting to note that Dr. T. J. J. SEE in his article in *A.J.* 344, relative to this binary star, previous to knowing of this value of the parallax, has argued for the probability of a parallax considerably larger than heretofore accepted.

Columbia College, New York City, 1895 June 18.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed July 13.*

THE

ASTRONOMICAL JOURNAL.

No. 350.

VOL. XV. BOSTON, 1895 AUGUST 5. NO. 14

NOTES ON VARIABLE STARS, — No. 9,

HENRY M. PARKHURST.

Results of Observations.

No.	Star	Phase	Observed Date Julian	Observed Date Calendar	E	Corr.	W	Remarks
				1894-95				
1574	*W Tauri*	Max.	3135:	Nov. 2	38	−12	1	Elements, *A.J.* 319. My own suggested period in *A.J.* 319, no better
"	"	Min.	3256:	Mar. 3	39	+45	1	
1577	*R Tauri*	Max.	3275	Mar. 22	37	−12	6	
1582	*S Tauri*	Max.	3227	Feb. 2	34	+ 5	3	Long interval in the observations
1717	*V Tauri*	Max.	3222	Jan. 28	48	+20	4	Revised elements, *A.J.* 319
"	"	Min.	3302:	Apr. 18	49	+20	1	Correction estimated to be the same
1761	*R Orionis*	Min.	3272:	Mar. 19	39	0	1	Prediction from elements ; obsns. not yet reduced
1805	*V Orionis*	Min.	3256	Mar. 3	6	–	2	Corresponds with $M-m = 118$; elements *A.J.* 347 : invisible more than two months
1923	*S Aurigae*	Max.	3136:	Nov. 3	–	–	1	Makes the last period 608 days ; *A.J.* 308
1941	*S Orionis*	Max.	3178	Dec. 15	22	+19	9	The same correction that I found in 1885
2013	*U Aurigae*	Min.	3153:	Nov. 20	4	–	0	Estimated from elements ; invisible more than 5 months
2100	*U Orionis*	Max.	3259	Mar. 6	9	+ 7	7	Elements *A.J.* 319. YENDELL makes corr. neg. *A.J.* 341
2266	*V Monocerotis*	Max.	3172	Dec. 9	13	− 6	8	
2478	*R Lyncis*	Min.	3239:	Feb. 14	20	–	–	Elements ; probably two or three weeks earlier
2528	*R Geminorum*	Min.	3214	Jan. 20	27	–	–	Elem. *A.J.* 319; observed changes too slow to be reliable
2539	*R Canis minoris*	Max.	3276.0	Mar. 23	39	+48	9	Closely agreeing with *A.J.* 319
2625	*V Geminorum*	Max.	3259	Mar. 6	20	−28	6	
2684	*S Canis minoris*	Max.	3209	Jan. 15	35	0	6	Agrees with 1893, *A.J.* 308
2735	*U Canis minoris*	Min.	3325	May 11	14	–	–	Elements ; minimum evidently occurs much later
(2903)	*— Cancri*	–	–	–	–	–	–	Possibly variable, $nP = 15$ days
2946	*R Cancri*	Max.	3171	Dec. 8	43	+18	8	
2976	*V Cancri*	Min.	3175	Dec. 12	32	+ 8	2	
"	"	Max.	3280.2	Mar. 27	32	+11	8	
3060	*U Cancri*	Max.	3224	Jan. 30	50	+49	3	Observations interrupted at time of maximum
3170	*S Hydrae*	Max.	3231	Feb. 6	54	− 6	3	
3184	*T Hydrae*	Max.	3308.3	Apr. 24	47	−28	9	
3186	*T Cancri*	Min.	3197	Jan. 3	28	− 5	1	Assuming uniform changes ; may have been 3 days earlier
3425	*X Hydrae*	–	–	–	–	–	–	Obsns. tend to confirm elements, *A.J.* 347
3477	*R Leonis min.*	Min.	3233	Feb. 8	30	− 3	4	
3493	*R Leonis*	Max.	3245:	Feb. 20	161	−50	1	Perhaps earlier ; much brighter than last year

Individual Observations.

1574 *W Tauri.*

(Continued from 319)

Julian	Calendar	Mag.
	1894	
3135.6	Nov. 2	9.7
3153.5	20	10.0
3168.5	Dec. 5	10.09_2
3182.6	19	11.06_2

1574 *W Tauri.*—Cont.

Julian	Calendar	Mag.
	1895	
3194.6	Dec. 31	10.8
3208.5	Jan. 14	11.3
3216.5	22	12.4
3236.5	Feb. 11	12.6
3242.6	17	12.9

1574 *W Tauri.*—Cont.

Julian	Calendar	Mag.
	1895	
3246.6	Feb. 21	12.8
3267.5	Mar. 14	12.8]
3276.4	23	12.8]
3294.5	Apr. 10	12.4
3298.5	14	12.0

1577 *R Tauri.*

(Continued from 319.)

Julian	Calendar	Mag.
	1895	
3221.5	Jan. 27	12.8
3236.5	Feb. 11	11.6
3239.5	14	11.1
3245.5	20	10.5

1577 *R Tauri.*—Cont.

Julian	Calendar	Mag.
	1895	
3263.5	Mar. 10	9.56_2
3270.5	17	9.69_2
3276.6	23	9.48_2
3283.5	30	9.62_2
3289.5	Apr. 5	10.24_2

1582 *S Tauri*

(Continued from 319.)

Julian	Calendar		Mag.
	1895		
3213.6	Jan.	19	10.7
3216.5		22	10.38_2
3221.5		27	10.2
3236.5	Feb.	11	10.8
3239.5		14	11.1
3245.5		20	11.6

1717 *V Tauri.*

(Continued from 319.)

	1894-5		
3182.6	Dec.	19	12.5
3194.6		31	11.5
3208.5	Jan.	14	10.6
3211.6		17	10.68_2
3216.5		22	10.29_2
3238.6	Feb.	13	10.67_2
3248.5		23	11.18_2
3269.5	Mar.	16	12.35_2
3272.5		19	12.37_2
3276.5		23	12.85_2
3281.5		28	13.0
3294.5	Apr.	10	13.3]

1805 *V Orionis.*

(Continued from 319.)

	1894-5		
3182.5	Dec.	19	13.0
3194.6		31	13.2
3208.5	Jan.	14	13.8
3218.5		21	14.0
3236.5	Feb.	11	14.0]
3246.6		21	14.0]
3267.5	Mar.	14	13.8]
3281.5		28	14.0:
3294.5	Apr.	10	14.0

1923 *S Aurigae.*

(Continued from 308.)

	1894-5		
3135.6	Nov.	2	10.5:
3136.6		3	9.6
3153.5		20	9.9
3166.5	Dec.	3	10.6
3181.5		18	10.5
3194.6		31	10.5
3208.6	Jan.	14	9.9
3211.6		17	10.6
3221.5		27	10.5
3239.5	Feb.	14	11.0
3246.6		21	11.0
3270.5	Mar.	17	11.0
3281.5		28	11.5
3298.5	Apr.	14	11.6

1944 *S Orionis.*

	1894		
3153.6	Nov.	20	10.3
3165.6	Dec.	2	10.1

1944 *S Orionis.*—Cont.

Julian	Calendar		Mag.
	1894		
3166.6	Dec.	3	9.54_2
3168.6		5	9.48_2
3169.6		6	9.01_2
3177.6		14	7.97_2
3180.6		17	8.43_2
3182.5		19	9.05_2
3183.6		20	8.53_2
3185.6		22	8.60_2

2013 *U Aurigae.*

(Continued from 319.)

	1894-5		
3136	Nov.	3 to	
3281	Mar.	28	12.0]
13 dates			
3298.5	Apr.	14	11.7
3305.6		21	11.7

2100 *U Orionis.*

(Continued from 319.)

	1895		
3213.6	Jan.	19	8.9
3239.5	Feb.	14	6.6
3240.5		15	6.75_2
3245.5		20	6.62_2
3251.5		26	6.51_2
3262.5	Mar.	9	6.50_2
3270.5		17	6.41_2
3276.6		23	7.02_2
3282.5		29	7.72_2

2266 *V Monocerotis.*

(Continued from 319.)

	1894		
3153.6	Nov.	20	6.7
3165.6	Dec.	2	6.86_2
3166.6		3	6.83_2
3168.6		5	6.62_2
3169.6		6	6.69_2
3177.6		14	6.46_2
3182.5		19	7.31_2
3183.6		20	7.09_2

2478 *R Lyncis.*

(Continued from 319.)

	1894-5		
3182.5	Dec.	19	12.9]
3213.6	Jan.	19	12.9]
3245.6	Feb.	20	11.8

2528 *R Geminorum.*

(Continued from 319.)

	1894-5		
3182.5	Dec.	19	11.7]
3194.6		31	12.0
3213.6	Jan.	19	12.0]
3221.5		27	12.0
3240.6	Feb.	15	12.1

2528 *R Gemin.*—Cont.

Julian	Calendar		Mag.
	1895		
3251.5	Feb.	26	12.0]
3270.5	Mar.	17	12.0]
3281.5		28	12.0]
3298.5	Apr.	14	12.0
3312.5		28	12.0]
3324.6	May	10	11.0

2539 *R Canis minoris.*

(Continued from 319.)

	1894-5		
3186.6	Dec.	23	9.87_2:
3195.6	Jan.	1	9.66_2
3197.6		3	9.96_2
3198.6		4	9.09_2
3208.6		14	8.96_2
3217.5		23	9.17_2
3240.5	Feb.	15	8.83_2
3250.5		25	8.25_2
3263.5	Mar.	10	7.65_2
3270.5		17	7.23_2
3276.6		23	7.47_2
3283.5		30	7.66_2
3289.5	Apr.	5	7.27_2
3294.5		10	7.85_2
3303.5		19	7.80_2

2625 *V Geminorum.*

(Continued from 319.)

	1895		
3239.5	Feb.	14	9.3
3241.5		16	9.13_2
3256.6	Mar.	3	8.40_2
3269.5		16	8.83_2
3274.5		21	8.79_2
3283.5		30	9.22_2
3289.5	Apr.	5	9.16_2

2684 *S Canis minoris.*

(Continued from 308.)

	1894-5		
3186.6	Dec.	23	7.40_2:
3195.6	Jan.	1	7.57_2
3197.6		3	7.57_2
3198.6		4	7.74_2
3208.6		14	7.40_2
3217.5		23	7.86_2
3240.5	Feb.	15	7.71_2
3251.5		26	8.97_2

2735 *U Canis minoris.*

(Continued from 326.)

	1895		
3239.5	Feb.	14	9.5
3245.5		20	10.87_2
3256.6	Mar.	3	10.86_2
3269.5		16	10.50_2
3272.5		19	9.60
3276.6		23	10.73_2

2735 *U Can. min.*—Cont.

Julian	Calendar		Mag.
	1895		
3283.5	Mar.	30	10.70_2
3294.5	Apr.	10	11.48_2
3303.6		19	11.81_2
3312.6		28	12.44_2
3324.6	May	10	12.6

(2903) — *Cancri.*

(Continued from 326.)

	1895		
3242.6	Feb.	17	12.8
3245.6		20	13.0
3251.5		26	12.8
3281.5	Mar.	28	12.8
3298.5	Apr.	14	12.7
3303.6		19	12.8
3305.5		21	13.25_2
3312.6		28	12.90_2
3326.6	May	12	13.04_2
3330.6		16	13.04_2

2916 *R Cancri.*

	1894		
3158.6	Nov.	25	7.5
3165.6	Dec.	2	7.2
3166.6		3	7.02_2
3168.6		5	6.62_2
3169.6		6	6.41_2
3177.6		14	6.87_2
3180.6		17	7.44_2
3183.6		20	7.39_2

2976 *V Cancri.*

(Continued from 326.)

	1894-5		
3158.6	Nov.	25	11.6
3182.6	Dec.	19	11.8]
3194.6		31	11.1
3213.6	Jan.	19	9.5
3249.5	Feb.	24	8.42_2
3256.6	Mar.	3	8.01_2
3269.6		16	8.05_2
3276.6		23	7.79_2
3283.6		30	7.61_2
3289.5	Apr.	5	7.77_2
3294.5		10	8.31_2
3298.5		14	8.01_2

3060 *U Cancri.*

(Continued from 326.)

	1894-5		
3158.6	Nov.	25	12.2]
3182.6	Dec.	19	10.9:
3186.6		23	12.58_2
3194.6		31	11.2
3197.6	Jan.	3	12.00_2
3211.6		17	11.48_2
3216.6		22	10.91_3
3240.6	Feb.	15	11.9

3170 *S Hydrae.*

(Continued from 326.)

Julian	Calendar		Mag.
	1895		
3213.6	Jan.	19	8.3
3242.5	Feb.	17	8.21_2
3249.5		24	8.31_2

3184 *T Hydrae*

	1895		
3240.6	Feb.	15	9.2
3251.5		26	9.32_2
3271.5	Mar.	18	9.02_2
3283.6		30	7.76_2
3289.6	Apr.	5	8.07_2
3294.6		10	7.87_2
3298.5		14	7.79_2
3303.5		19	7.15_2
3312.5		28	7.88_2
3320.5	May	6	7.63_2
3324.6		10	7.87_2
3326.5		12	7.68_2
3341.6		27	8.61_2

3186 *T Cancri.*

	1894-5		
3183.6	Dec.	20	9.47_2
3211.6	Jan.	17	9.47_2
3242.5	Feb.	17	9.21_2

3425 *X Hydrae.*

	1895		
3211.6	Jan.	17	13.0]
3216.6		22	13.0]
3242.6	Feb.	17	12.5]
3245.6		20	12.7
3249.6		24	12.5
3271.5	Mar.	18	12.22
3274.6		21	11.86_2
3283.6		30	12.34_2
3305.5	Apr.	21	11.02_2
3321.6	May	10	10.24_2
3312.6		28	8.8

3477 *R Leonis minoris.*

(Continued from 326.)

	1895		
3213.6	Jan.	19	11.8
3240.6	Feb.	15	12.6
3245.6		20	12.51_2
3270.6	Mar.	17	11.9

3493 *R Leonis.*

(Continued from 326.)

	1895		
3242.6	Feb.	17	4.86_2
3250.5		25	5.01_2
3272.5	Mar.	19	5.43_2
3283.6		30	5.66_2
3294.6	Apr.	10	6.29_2

COMPARISON-STARS FOR 3425 *X Hydrae.*

X	−14°2887	8.77	5	3*T*	−14°2907	9.03	3*M*	*Z*	−14°2890		11.16	4	*m*	2*n*2*f*	*V*	13.00	2
T	−14°2899	10.08	1	*U*	−14°2894	9.78	4	*i*	2*n*1*f*	*Z*	12.27	2	*n*	2*n*2*f*	*m*	13.13	1
2*T*	−15°2850	8.63	3*M*	1*U*	−14°2915	9.54	3*M*	*k*	2*s*2*p*	*U*	12.63	2					

SUNSPOT OBSERVATIONS,

MADE AT PHILADELPHIA, PENN., WITH A 4½-INCH REFRACTOR,

By A. W. QUIMBY.

1895	Time	New Gps	Total		Fac. Grs.	Def.
			Gps.	Spots		
Jan. 1	10	1	6	17	4	poor
2	10	1	6	20	4	poor
3	12	–	6	32	2	good
4	10	–	6	52	3	good
5	8	–	3	9	–	v.poor
7	9	–	3	12	–	v.poor
11	10	–	4	41	3	fair
12	9	–	4	22	3	poor
13	10	–	3	12	3	poor
14	9	1	2	10	3	poor
15	12	1	3	7	4	poor
17	10	2	5	13	3	fair
18	10	3	7	18	3	fair
19	1	–	6	40	3	fair
20	1	–	7	41	4	fair
22	10	1	4	34	3	fair
23	9	1	5	17	2	fair
24	9	1	7	34	3	fair
25	10	–	6	27	2	poor
26	12	–	4	34	2	poor
27	9	1	5	68	4	fair
28	9	4	9	97	3	good
29	1	1	8	64	2	fair
31	10	2	10	70	2	fair
Feb. 1	9	–	8	72	2	fair
2	2	1	5	22	2	v.poor
3	9	–	8	32	2	poor
4	2	–	6	51	4	fair
5	10	–	3	22	2	poor
6	10	–	3	12	2	poor
8	10	–	3	12	1	poor
9	10	2	4	11	2	poor
10	9	–	4	11	2	poor
11	2	1	3	21	2	fair
12	9	–	3	11	2	poor
13	12	–	3	9	1	poor
14	10	1	4	8	3	fair
15	10	2	5	13	2	poor
17	9	1	6	26	2	fair
18	11	1	7	20	3	poor
19	11	–	6	23	2	fair
20	9	–	6	26	2	poor
21	3	–	5	29	2	poor
22	10	–	5	26	2	fair
23	10	1	6	34	3	fair
24	10	3	9	41	3	poor
25	9	–	5	24	2	poor
26	9	1	8	32	2	poor
27	9	2	10	45	2	poor
28	9	–	4	20	–	v.poor
Mar. 1	9	1	9	52	2	fair
2	5	–	5	18	1	v.poor
3	10	–	5	26	2	poor
Mar. 4	12	–	5	22	2	poor
5	10	1	5	12	1	poor
6	2	3	6	29	2	poor
7	9	–	6	20	2	poor
8	12	–	5	12	1	v.poor
9	12	1	5	27	3	fair
10	10	2	6	32	2	fair
11	11	–	5	12	–	v.poor
14	9	–	5	26	2	fair
16	9	4	9	25	2	fair
17	9	–	5	32	2	poor
18	9	–	3	20	2	poor
19	9	1	4	33	2	fair
20	9	–	2	10	–	v.poor
21	9	1	4	43	1	poor
22	9	–	4	45	2	poor
23	2	1	5	50	3	fair
24	10	–	3	41	2	poor
25	5	–	3	24	3	poor
26	9	2	5	36	3	good
27	12	–	4	14	2	poor
28	9	–	3	36	1	good
29	10	1	3	32	2	fair
30	8	–	3	32	3	fair
31	10	1	4	30	2	fair
Apr. 2	11	2	6	28	3	fair
3	11	–	5	36	3	fair
4	9	–	5	23	3	fair
5	10	1	6	14	3	poor
6	8	–	4	14	2	poor
7	8	–	4	12	1	poor
9	8	1	5	23	3	fair
10	7	–	5	10	1	poor
11	9	3	7	20	3	fair
12	10	1	7	25	2	fair
14	9	–	5	31	3	fair
15	9	–	4	30	2	fair
16	2	–	4	42	1	good
17	9	–	4	29	2	fair
18	8	1	3	32	2	fair
19	8	2	4	36	2	fair
20	8	1	5	38	3	fair
21	8	2	7	44	3	fair
22	8	–	7	42	4	fair
23	8	1	6	47	4	fair
24	8	1	7	56	4	fair
25	10	1	8	51	3	fair
26	8	1	8	45	3	fair
May 1	2	–	4	23	2	poor
2	8	2	5	24	3	fair
3	11	–	4	13	2	fair
4	10	–	3	26	4	fair
5	–	–	1	15	4	fair
May 6	12	–	2	13	3	fair
*7	9	–	1	8	1	poor
8	12	1	2	9	1	poor
9	8	1	3	12	4	fair
10	8	1	3	11	3	poor
11	8	–	2	7	1	fair
12	4	1	3	15	1	fair
13	10	1	4	14	1	fair
14	2	–	2	14	2	poor
15	8	–	3	20	2	poor
16	8	–	2	13	1	poor
17	10	1	3	29	2	fair
18	8	–	4	24	4	good
19	1	1	5	31	4	fair
20	8	1	5	26	4	good
22	7	–	5	42	2	fair
*23	7	–	5	24	1	poor
24	7	2	7	32	2	poor
26	6	2	8	72	2	poor
27	8	–	8	62	2	poor
28	8	–	6	57	2	poor
29	8	1	5	52	3	fair
30	8	–	5	26	4	good
31	7	1	5	33	2	fair
June 1	7	–	3	30	2	fair
2	8	3	5	43	3	fair
3	8	1	5	43	3	fair
4	3	–	4	39	2	good
5	4	3	7	48	2	good
6	8	1	6	60	2	fair
7	8	–	5	38	2	fair
8	7	–	5	40	2	fair
9	5	1	6	41	2	fair
10	8	1	6	37	3	fair
11	11	–	6	28	3	fair
12	10	–	3	30	2	poor
13	11	1	5	32	3	fair
14	11	–	5	52	5	fair
15	8	–	5	72	5	fair
16	8	1	5	101	5	fair
17	8	–	5	72	2	fair
18	8	1	4	102	3	fair
19	8	–	4	83	2	fair
20	8	–	4	45	2	fair
21	8	–	4	20	–	v.poor
23	8	–	5	48	2	fair
24	9	1	5	26	2	fair
25	7	–	4	32	2	fair
26	8	–	3	26	2	fair
27	8	–	3	18	2	fair
28	8	1	4	32	1	fair
29	8	–	4	27	1	fair
30	4	1	5	17	2	fair

* 2¼-inch Refractor.

ON THE CORRECTION OF PHOTOGRAPHIC MEASURES FOR REFRACTION,

BY HAROLD JACOBY.

Various formulas have been published for freeing the measured rectangular coordinates of star-images on a photographic plate from the effect of refraction. Those of RAMBAUT (*A.N.* 3125 and *Trans. Royal Irish Acad.* Vol. XXX, p. 241), are the most convenient, and they are sufficiently accurate when the zenith-distance and declination are not too great. Dr. RAMBAUT finds that the corrections required by the measured X and Y on the plate, are of the form

$$M_x X \sec\delta + N_x Y \quad \text{for } X\sec\delta$$
$$M_y X \sec\delta + N_y Y \quad \text{for } Y$$

where X and Y correspond respectively to differences of right-ascension and declination, and δ is the declination of the center of the plate. The coefficients, M_x, etc., are functions of the latitude, and of the hour-angle and declination of the center of the plate, and are therefore constant for all stars upon it. The formulas owe their convenience to this circumstance; and with them the labor of correcting for refraction is practically limited to the computation of the coefficients M_x, etc. For the measures must be corrected in any case for errors of orientation and scale-value; and as these corrections are of the same form as the above refraction-corrections, the two can be applied together as easily as one alone.

Formulas for M_x, etc., have also been given by Prof. TURNER (*M.N. R.A.S.* LIV, p. 18), and while he has deduced them in an ingenious way, he has omitted a necessary step, and his results are therefore incorrect. He finds M_y and $N_x \cos^2\delta$ equal, while in RAMBAUT's formulas they differ; and this appears to have escaped his notice, though in his paper the two sets of formulas are given side by side for comparison. The following formulas are rigorously equivalent to RAMBAUT's, but are perhaps a little more convenient, especially as a great part of the computation can be effected without using logarithms. In these formulas G and H are the same as Prof. TURNER's X and Y, and in RAMBAUT's notation they correspond to $\chi\cos\delta$ and ϕ. The hour-angle is $(\theta-\alpha)$.

$$\begin{aligned}
\sin n \sin N &= \cos\phi\cos(\theta-\alpha)\\
\sin n \cos N &= \sin\phi\\
G &= \cot(\delta+N)\\
H &= \tan(\theta-\alpha)\sin N \operatorname{cosec}(\delta+N)\\
\tan^2\zeta &= G^2+H^2\\
M_x &= k(1+H^2-G\tan\delta)\sin 1''\\
N_x &= \tfrac{1}{15}k(GH\sec\delta-H\tan\delta\sec\delta)\sin 1''\\
M_y &= 15k(GH\cos\delta+H\sin\delta)\sin 1''\\
N_y &= k(1+G^2)\sin 1''
\end{aligned}$$

These formulas will give the correction for $X\sec\delta$ in seconds of time, and for Y in seconds of arc. Log k can be taken from the Besselian refraction-table, with the argument "true zenith-distance;" but it must then be increased by the quantity

$$\log(1+\tfrac{1}{65}) \text{ or } 0.0066,$$

to allow for the difference between the photographic and visual refraction-constants. (HENRY Brothers, *Bull. Com. Perm.* 1, 164, SCHEINER and RAMBAUT, *A.N.* 3255).

The above formulas, in common with those of RAMBAUT, have the disadvantage that the auxiliary quantities are functions of the hour-angle, as well as the latitude and declination. If, therefore, we wish to tabulate the coefficients M_x, etc., as functions of the hour-angle and declination, for a given latitude, we must compute all the auxiliaries for each value of both declination and hour-angle. We can avoid this difficulty, and at the same time render our formulas much more convenient, if we expand the coefficients M_x, etc., in ascending powers of the hour-angle. The resulting series will generally converge rapidly, because most astronomical photographs of precision are taken near the meridian.

If we put $t = \theta-\alpha$, we have

$$\tan N = \cot\phi\cos t,$$

and therefore to terms of the third order inclusive,

$$N = \frac{\pi}{2}-\phi+\tan^2\tfrac{1}{2}t\sin 2\phi$$

and to the same order of accuracy,

$$\begin{aligned}
G &= \tan(\phi-\delta)+\tfrac{1}{4}t^2\sec^2(\phi-\delta)\sin 2\phi\\
H &= t\cos\phi\sec(\phi-\delta)-t^3\cos\phi\sec(\phi-\delta)\\
&\qquad [\tfrac{1}{2}\sin\phi\sec(\phi-\delta)\sin\delta-\tfrac{1}{3}]
\end{aligned}$$

We might employ these formulas for computing G and H, and then proceed as before. But, when the hour-angle does not exceed one hour, we may neglect terms in t^3. We then obtain, after some reduction, and introducing the auxiliary λ, the following system of formulas, in which none of the auxiliaries depend upon the hour-angle. In these formulas, t is to be expressed in minutes of time.

$$\tan\lambda = \tfrac{1}{2}\tan\phi$$

$$\begin{array}{ll}
\omega_1 = k\cos\phi\sec(\phi-\delta)\sec\delta\sin 1'' & \log k\sin 1'' = 6.4532\text{–}10\\
\omega_2 = \tfrac{1}{4}k\sin 2\phi\sec^2(\phi-\delta)\sec\delta\cos(\lambda+\delta)\operatorname{cosec}\lambda\sin^2 1^{m}\sin 1'' & \log\tfrac{1}{4}k\sin 1''\sin^2 1^{m} = 1.1308\text{–}10\\
\omega_3 = \tfrac{1}{15}k\sin(\phi-2\delta)\cos\phi\sec^2\delta\sec^2(\phi-\delta)\sin 1^{m}\sin 1'' & \log\tfrac{1}{15}k\sin 1^{m}\sin 1'' = 2.9169\text{–}10\\
\omega_4 = \tfrac{15}{2}k\sin 2\phi\sec^2(\phi-\delta)\sin 1^{m}\sin 1'' & \log\tfrac{15}{2}k\sin 1^{m}\sin 1'' = 4.9681\text{–}10\\
\omega_5 = k\sec^2(\phi-\delta)\sin 1'' & \log k\sin 1'' = 6.4532\text{–}10\\
\omega_6 = \tfrac{1}{15}\omega_4\tan(\phi-\delta)\sin 1^{m} & \log\tfrac{1}{15}\sin 1^{m} = 6.4637\text{–}10
\end{array}$$

$$M_x = \omega_1 + \omega_2 t^2$$
$$N_x = \omega_3 t$$
$$M_y = \omega_4 t$$
$$N_y = \omega_5 + \omega_6 t^2$$

And, as before, if X and Y have been measured on the plate, we must add to $X \sec\delta$, the correction

$$M_x X \sec\delta + N_x Y,$$

and to Y the correction,

$$M_y X \sec\delta + N_y Y$$

The coefficients in the formulas are so arranged that the correction for $X \sec\delta$ will come out in seconds of time, and for Y in seconds of arc, if $X \sec\delta$ and Y are expressed in seconds of time and arc respectively. The limitations of these formulas are the same as those of Rambaut's formulas, with the added limitation that the hour-angle must not exceed one hour. This last condition will generally be fulfilled, especially for the plates of the astro-photographic catalogue. The quantities ω_1, etc., are readily tabulated for a given latitude, with the argument δ; and the computation of M_x, etc., then requires but a mere trifle of labor. When the zenith-distance does not exceed 45°, we may safely give to $\log k$ a constant value, taken from Bessel's refraction-tables. The coefficients given on the right-hand side of the above formulas are computed with this value, taking account also of the difference between the visual and photographic refraction constants. The above principle of expanding the refraction-coefficients may probably also be applied at very high declinations, when we may employ ascending powers of the polar distances, as well as the hour-angle.

As an example of the use of the above formulas, I have computed the refraction-coefficients for the latitude of Paris (48° 50′), and declination 24°.

The numbers obtained are:

$\omega_1 = .000225$ $\omega_2 = .0000000212$ $\omega_3 = .0000000115$
$\omega_4 = .0000112$ $\omega_5 = .000345$ $\omega_6 = .0000000151$

From these we readily find with Crelle's tables:

t	M_x	N_x	M_y	N_y
0^{m}	.000225	.0000000	.00000	.000345
10	.000226	.0000000	.00011	.000345
20	.000226	.0000000	.00022	.000346
30	.000227	.0000000	.00034	.000346
40	.000229	.0000000	.00045	.000347
50	.000231	.0000001	.00056	.000349
60	.000233	.0000001	.00067	.000350

M_x and N_y are always positive; N_x and M_y are negative for negative hour-angles.

The above little table, requiring with the ωs less than half an hour in computation, contains all that is necessary for the refraction-correction of the 24° belt of the astro-photographic catalogue; except, of course, that the coefficients M_x, etc., may need to be multiplied by the usual meteorological factor, whose logarithm can be taken from the Besselian refraction-tables.

Royal Observatory, Cape of Good Hope, 1895 *April* 24.

MAXIMA AND MINIMA OF VARIABLE STARS,

By W. E. Sperra.

The following observations, except those of *W Virginis*, extend from 1894 September to 1895 May, and were made with a 3-inch refractor, by the Argelander method. The magnitudes, unless otherwise stated, are on the historic scale. Where time is expressed in a decimal of a day, Greenwich Mean Time is referred to.

1623. *T Camelopardalis.*

Twenty-one observations, from 1894 Dec. 3 to 1895 Mar. 2, yield the date of maximum 1895 Jan. 3, at $7^{M}.8$. The rise was rapid and the fall more slow, both were regular.

1981. *S Camelopardalis.*

Thirty-eight observations, from 1894 Dec. 3 to 1895 May 27, give a maximum for 1895 Feb. 13, at $8^{M}.5$. The star was at the $9^{M}.0$ when observation commenced, and at last observation had returned to that magnitude. From Jan. to April it fluctuated between $8^{M}.3$ and $8^{M}.6$, making the curve very flat at maximum.

2100. *U Orionis.*

Twenty-seven observations, beginning 1895 Jan. 14, when the star was at $8^{M}.5$, and extending to April 23 when the star had fallen to $7^{M}.8$, indicate the date of maximum quite definitely for 1895 Feb. 24, at $6^{M}.7$. All observations but four are within a step (0.06 mag.) of curve. After the star remained stationary at $6^{M}.7$ for about ten days, it suddenly rose 0.4 mag. higher, and as suddenly fell back to $6^{M}.7$. This sudden fluctuation was accomplished in less than ten days.

2815. *U Geminorum.*

I have the following observations of December, 1894, and March, 1895, maxima. Neither set gives the date of maximum. The magnitudes are on Baxendell's photometric scale.

1894 Dec.	4.75	$<12^{M}.3$
	6.94	9.6
	8.90	10.0
1895 March	6.55	9.7
	10.65	9.5
	14.60	9.7
	16.55	10.4
	17.60	11.2
	18.55	12.3

1521. *R Virginis.*

Fifteen observations, from 1895 Feb. 4 to April 23, yield a minimum for 1895 March 19, at 9^{M}.7. Star was at 8^{M}.5 when observation commenced, and at last observation it had again reached that magnitude.

1557. *S Ursae Majoris.*

A minimum for 1894 Nov. 26, at 11^{M}.4, and a maximum for 1895 March 18, at 7^{M}.6, are indicated by thirty-two observations from 1894 Sept. 23 to 1895 May 4.

5157. *S Bootis.*

Fourteen observations, from 1895 Jan. 27 to April 2, indicate a maximum for 1895 Feb. 7, at 8^{M}.4. Mag. only approximate. The rise was rapid, and the fall slow and irregular.

5194. *V Bootis.*

Eighteen observations, commencing 1895 Jan. 1, when the star was of 8^{M}.0, and extending to April 10, when star had returned to same magnitude, gives the date of maximum quite definitely for 1895 Feb. 23, at 7^{M}.4. The rise was a little slower than the fall, and observations are close to curve.

6207. *Z Ophiuchi.*

Twenty observations, covering the period from 1895 Feb. 23 to May 29, give the date of maximum for 1895 Mar. 28, at 8^{M}.2. The rise was considerably more rapid than the fall. The star was at about 8^{M}.7, when observation commenced, and a little below that at last one. The observations are somewhat discordant, and therefore the date of maximum may be uncertain by a day or two.

7085. *RT Cygni.*

A maximum, 1894 Dec. 17, at 6^{M}.9, and a minimum, 1895 April 12, at 11^{M}.5 (the assumed limit for my eye and glass), are indicated by thirty-eight observations, from 1894 Nov. 25 to 1895 May 24. The rise is rapid, and the fall quite slow for about sixty days after maximum. The star then falls more rapidly to minimum.

SHORT-PERIOD VARIABLES.

I have the following maxima and minima of three of the short-period stars observed with same instrument.

2279. *T Monocerotis.*

Twenty-one observations, from 1895 March 18 to May 1, yield a maximum March 28.0, at 6^{M}.1; a minimum April 16.0, at 6^{M}.8, and another maximum April 25.2, at 6^{M}.1.

4805. *W Virginis.*

Ten observations, from 1894 June 19 to July 8, give a maximum June 21.9, at 8^{M}.5, and a minimum July 1.4, at 9^{M}.6. The magnitudes are only approximate.

7437. *X Cygni.*

Twenty observations, from 1894 Dec. 19 to 1895 Feb. 4, yield a maximum 1894 Dec. 25.65, at 6^{M}.3, a minimum 1895 Jan. 22.55, at 6^{M}.9, and another maximum for 1895 Jan. 27.90, at 6^{M}.3.

OBSERVATIONS OF *MIMAS* AND *ENCELADUS*,

MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY,

BY ORMOND STONE.

The following measures are a continuation of the observations of the satellites of *Saturn* given in *A.J.* 347. The angles given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction.

Mimas–Enceladus.

1894	Eastern Time	*p*	Eastern Time	*s*
	h m s	°	h m s	″
Apr. 29	12 5 36	90.25	12 13 54	65.23
	12 25 34	91.29	12 16 50	65.30
May 1	8 11 19	159.19	8 22 59	1.74
10	8 25 37	59.63	8 32 57	7.63
	8 11 57	60.23	8 35 3	7.84

Mimas–Tethys.

1894	Eastern Time	*p*	Eastern Time	*s*
Apr. 30	10 16 58	257.10	10 55 52	17.31
	11 3 13	256.86	10 57 43	17.36

Mimas–Dione.

1894	Eastern Time	*p*	Eastern Time	*s*
Apr. 30	11 12 41	121.85	11 21 53	24.60
	11 32 47	126.40	11 24 16	24.28

Enceladus–Tethys.

1894	Eastern Time	*p*	Eastern Time	*s*
	h m s	°	h m s	″
Mar. 13	11 39 30	309.37	. . .	. .
	11 43 28	308.91	. . .	. .
Mar. 14	13 56 3	34.10	. . .	. .
	14 1 33	36.64	. . .	. .
30	11 7 17	81.27	11 14 15	14.71
Apr. 14	14 16 29	82.94	14 23 51	21.24
24	11 0 26	109.31	11 10 2	10.46
	11 17 42	109.75	11 12 52	10.24
29	12 35 4	68.48	12 39 24	11.40
	12 47 29	69.52	12 41 11	11.39
May 8	10 12 47	66.72	10 20 58	21.85
	10 30 49	67.90	10 21 10	21.80
15	9 36 22	220.68	9 41 57	17.27
	9 53 26	226.15	9 45 14	17.34
June 3	9 18 35	244.47	9 22 27	6.73
	9 28 17	243.51	9 24 54	6.80
23	8 41 39	80.66	8 53 18	11.38
	8 59 33	82.15	8 56 15	11.53

Enceladus–Dione.

1894	Eastern Time	*p*	Eastern Time	*s*
Mar. 21	13 40 36	28.90	13 41 12	8.02
	13 49 34	31.04	13 45 10	8.15
27	11 25 57	351.20	11 35 51	7.51
	11 42 25	352.40	. . .	. .

Enceladus–Dione.—Cont.

1894	Eastern Time	p	Eastern Time	s
	h m s	°	h m s	″
Mar. 30	11 43 45	67.30	. . .	. .
Apr. 29	13 7 26	65.29	13 17 12	22.28
	13 25 46	66.89	13 18 59	22.48
May 10	9 57 31	57.65	10 5 47	13.49
	10 19 15	59.01	10 6 14	13.48
15	9 11 4	65.12	9 16 44	16.51
	9 25 28	65.66	9 20 56	16.29
June 3	9 49 23	43.13	9 53 41	13.91
	10 0 27	46.26	9 56 36	13.89
14	9 0 45	49.36	9 6 2	15.12
	9 15 39	52.93	9 9 27	15.33
23	9 4 25	74.74	9 11 28	25.69
	9 18 53	75.45	9 12 49	25.69

Enceladus–Rhea.

1894	Eastern Time	p	Eastern Time	s
	h m s	°	h m s	″
Mar. 13	14 2 57	276.05	15 15 15	105.08
	14 7 56	276.81	15 19 32	104.61
	14 13 32	276.31	. . .	. .
Apr. 27	9 58 11	267.67	10 7 0	45.80
	10 19 50	267.48	10 10 1	45.84
June 3	10 9 19	35.96	10 14 33	18.40
	10 20 41	37.95	10 17 23	18.59
23	9 28 3	101.89	9 36 4	28.16
	9 44 14	101.81	9 39 39	28.23

Enceladus–Titan.

1894	Eastern Time	p	Eastern Time	s
Apr. 16	10 10 48	125.64	10 25 16	65.69
	10 36 56	126.60	. . .	. .

OBSERVATIONS OF MINOR PLANETS.

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY JOHN H. OGBURN.

1895 Albany M.T.	*	No. comp.	Planet — *		Planet's Apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
				(6) *Hebe.*				
h m s			m s	′ ″	h m s	° ′ ″		
Mar. 5 8 14 28	1	4	−3 34.52	+4 57.6	11 18 57.06	+15 29 27.5	*n*9.602	0.694
9 7 20 28	2	5	−1 57.70	+0 33.3	11 15 28.78	16 6 57.9	*n*9.632	0.712
17 9 54 12	3	7	+0 56.37	−4 20.8	11 8 31.04	17 16 7.5	*n*9.253	0.593
21 8 2 19	4	6	+2 9.98	−1 8.4	11 5 20.34	17 45 8.7	*n*9.520	0.635
25 9 38 8	5	7	+1 2.65	−6 19.8	11 2 14.99	+18 11 51.5	*n*9.144	0.571
				(287) *Nephthys.*				
Mar. 3 9 5 12	6	7	−1 38.20	+3 13.3	10 24 59.47	+14 43 39.7	*n*9.445	0.650
5 8 58 56	7	13 , 5	+0 2.41	+9 47.4	10 23 16.49	15 2 28.7	*n*9.438	0.645
17 8 43 42	8	5	−0 36.91	−0 48.1	10 14 7.47	+16 40 35.1	*n*9.317	0.607

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 22 29.40	+2.18	+15 24 41.2	−11.3	Paris 14003
2	11 17 24.21	2.27	16 6 35.5	10.9	Paris, Armagh II
3	11 7 32.36	2.31	17 20 38.0	9.7	Astr. Gesellsch. Berlin
4	11 3 8.02	2.34	17 46 26.3	9.2	Paris, Brussels, Cincinnati
5	11 1 10.06	2.28	18 18 19.4	8.1	Greenwich 1880, Glasgow II
6	10 26 35.49	2.18	14 40 34.0	7.6	F. 46 *Leonis*
7	10 23 11.88	2.20	14 52 48.7	7.4	Paris, Glasgow, Brussels
8	10 14 42.16	+2.22	+16 41 28.5	− 6.2	Astr. Gesellsch. Berlin

The positions of stars 3 and 8 have been kindly forwarded by Dr. AUWERS, upon the application of Prof. BOSS.

NEW SHORT-PERIOD VARIABLE,

BY ALEX. WM. ROBERTS.

The star Cordoba Z.C. XII, 903, whose position for 1875.0 is R.A. = $12^h\ 14^m\ 33^s$, Decl. = −61° 35′ 15″ is a variable of short period.

I have suspected its variation for some time, but owing to its close proximity to (4429) I have hesitated to announce variation until I should be certain that its light-changes were in no way dependent upon (4429).

All the changes can be well represented by a period of 6.669 days, the period of increase being only 2.73 days.

The limits of variation are $6^M.8$ and $7^M.6$.

This star is Gen. Catal. 16832 = Lac. 5108; and should receive the name *T Crucis*. — ED.

A SOLAR PROMINENCE.

By J. B. COIT.

Upon the afternoon of June 11, 1895, a prominence was observed at the Boston University Observatory, which presented phenomena sufficiently interesting, it would seem, to warrant making it a matter of separate record.

The observations were made in the C line of the third spectrum.

The seeing was good throughout, and, at times, even excellent.

At $2^h\ 17^m$, W. M. T., with the slit tangential at position angle 243°, a very brilliant prominence was discovered.

When first observed, the prominence rested upon the Sun with a broad base and widened out at the top, somewhat more toward the south than the west point of the sun's limb. Upon the side toward the west a pendant streamer reached down to the chromosphere and extended upon it some 15″, far exceeding it in brilliancy. Upon the south side, at the top of the prominence, there was a slight cloud-like development outward and southward. Otherwise the top of the formation was quite regular, and there were no spikes nor sharp tongues of flame. Had it not been for the great brilliancy, there would have been little, viewed with an open slit, to attract attention. At this time the height was 74″. At $2^h\ 22^m$ the south preceding corner showed decided changes in form, and an increase in altitude.

From this time on, with no exception noticed of any importance, all the development was from this point alone, a pronounced drift to the south accompanying the ascent. The increase in altitude was not marked at any time by spikes or sharp-pointed flames of any kind, but there seemed rather to be an unfolding and detaching of cloud-like forms.

While this was going on, the main body of the prominence *decreased* in altitude. Thus, at $2^h\ 36^m$, when the ascending portions had reached an altitude of 86″, the altitude of the main body had decreased to 50″, retaining its outer boundary fairly uniform, though the body itself began to show signs of breaking up. At $2^h\ 49^m$ this portion was much broken by rifts, and it was difficult to escape the impression that the material here was breaking up, setting toward the limb of the sun and drifting southward to supply the outflow which soon after became much more pronounced and rapid. At this time a small detached cloud was seen above the main part floating *from* the south, with little or no motion upward.

In the following table the altitudes refer to the most elevated portion of the succession of cloud-like forms which ascended from the south "corner" of that which has been referred to as the "main" part of the prominence.

W.M.T.			Height in seconds of arc.	Height in kilometers.	Ascent per second in kilometers.
h	m	s	″		
2	17	–	74	53580	–
	36	–	86	62260	8
	55	3	117	84710	20
	59	18	166	120180	139
3	0	18	178	128870	145
	1	18	197	142630	229
	3	3	209	151320	83
	6	58	244	176660	108
	12	0	252	182450	19
	14	0	266	192580	84
	17	18	277	200550	40
	19	28	289	209240	67
	27		105	76020	-
	47	–	80	57920	–

The fluctuations in the velocity of ascent, often noted in "eruptive" prominences, are worthy of special attention. These might be accounted for by a dissolution of the cloud observed as being outermost, or by an oversight in detecting the highest cloud.

The writer, however, believes that the fluctuations indicated in the table were real, as doubtless are those reported by other observers. If so, then the ascending matter was operated upon by violent, irregular forces and restraints quite distinct from those operating in the neighborhood of the chromosphere and determining the velocity at lower elevations. At $3^h\ 7^m$ the obliquely ascending column consisted entirely of detached clouds.

In taking the transit at $3^h\ 19^m$, nothing whatever was seen for one-third the distance between the most elevated portion and the limb of the sun. After this, nothing was seen save an irregular mass attached but slightly to the sun. No observation was made after $3^h\ 47^m$.

The *form* of the ascending column and the fact that the development was wholly from one "corner" of the main part of the prominence, while this part for a time at least *decreased* in altitude, seem somewhat out of harmony with the theory of matter ejected violently from the sun.

Of course it is possible that two prominences were observed, lying in nearly the same line of sight, but this would offer only a partial explanation.

The form of the prominence so engrossed the attention that no study was made of the reversed lines.

CORRECTION TO THE *CONNAISSANCE DES TEMPS.*

An error of one minute in the right-ascension of γ^2 *Sagittarii* has been reproduced every year since the introduction of the star into the list, in 1889, and has not been corrected in the list up to 1897.

The right-ascension should be diminished by one minute; for 1895 it should be $17^h\ 59^m\ 3^s$, in place of $18^h\ 0^m\ 3^s$.

R. H. TUCKER.

Mt. Hamilton, 1895 July 18.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed July 31.*

THE
ASTRONOMICAL JOURNAL.
No. 351.

VOL. XV. BOSTON, 1895 AUGUST 15. NO. 15

THE GREAT INEQUALITY OF *JUPITER* AND *SATURN*,

By EDGAR ODELL LOVETT.

The Great Inequality of *Jupiter* and *Saturn* is a long-period inequality depending upon the difference between twice the mean motion of *Jupiter* and five times that of *Saturn*, in virtue of which the line of conjunctions slowly advances, and the planets return to their original configurations after periods of about 929 years.

As early as 1625 Kepler remarked, on comparing the observations of Tycho Brahe with those of Ptolemy, that the observed places of *Jupiter* and *Saturn* could not be reconciled with the admitted values of their mean motions (*Keplerus et Berneggerus, Epistolae mutuae*, p. 70; 12° Argentorati, 1672; also, *Keplerus*, Opera VI, p. 617, 1866). The errors of both planets were found to increase continually in the same direction, with this difference, that the tables made the mean motion of *Jupiter* too slow, and that of *Saturn* too rapid.

In his memoir on the aphelia and eccentricities (*Phil. Trans.*, 1676, p. 683) Halley was led to the belief that the anomalous irregularities of the two planets were due to their mutual attraction. He also attempted to determine the magnitude of the inequality for each planet, and concluded from his researches that in 2000 years the acceleration of *Jupiter* amounted to 3° 49′, and the retardation of *Saturn* to 9° 16′. In his tables of the planets he represented the errors by two secular equations, increasing as the square of the time, the one being additive to the mean motion of *Jupiter*, and the other subtractive from the mean motion of *Saturn* (see Grant's *History of Physical Astronomy*, pp. 47 et seq.; and Houzeau's *Vade-mecum de l'Astronomie*, § 246).

By comparing tables made at different epochs, Flamsteed confirmed the opinion that *Jupiter* was being steadily accelerated, and *Saturn* retarded (Flamsteed, J., *Exact Account of the Three Late Conjunctions of Jupiter and Saturn, London Phil. Trans.*, 1685, p. 244).

The most startling conclusions were drawn from these variations in the planetary motions. It was known that when the angular velocity of a body increases from century to century it must be approaching the center of motion; on the other hand a diminution in this velocity would indicate a recession of the planet from the sun. Hence it was inferred that the solar system would in the course of ages lose two of its most prominent members — that *Jupiter* would fall into the sun, while *Saturn* would be driven away into the depths of space. Euler and Lagrange had searched in vain for the cause of the anomalous behavior of *Jupiter* and *Saturn*, which appeared to be inconsistent with the law of gravitation; but in their researches they had neglected terms of the perturbations depending upon the cubes and higher powers of the eccentricities. In 1785 Laplace discovered from other considerations, that if we assume an acceleration of *Jupiter* a retardation of *Saturn* will necessarily result, and that in the very proportion observed; hence he set himself to examine the terms depending on the cubes of the eccentricities, and at once encountered the argument, $5n't-2nt+\text{const}$. Taking account of the fact that five times the mean motion of *Saturn* is nearly equal to twice the mean motion of *Jupiter*, and that in virtue of the double integration for the perturbation in longitude, these terms are affected by the small divisor, $5n'-2n$, in the second power, he did not hesitate to conclude that the long inequality depends on terms having this argument. Computation at once confirmed this hypothesis, and made known the cause and law of the great inequality. From the nature of the cause thus made known Laplace immediately perceived that there would arise in other parts of our system similar long inequalities depending on near approach to commensurability in the mean motions. In the *Mécanique Céleste* and subsequent works on Physical Astronomy these long-period inequalities have been determined. The explanation of these long-period perturbations by the law of gravitation was justly regarded by Laplace as one of the strongest proofs of the exactness of this law. The theorems relative to the stability of the eccentricities, inclinations, and major axes of the planetary orbits previously enunciated, could of course be regarded as valid only after the discovery that the long-period inequalities result from the theory of universal gravitation.

The principal coefficient of the great inequality, as it affects the mean longitude of *Jupiter*, has been determined as follows:

1785. Laplace (*Mémoires de l'Academie des Sciences.* 1785. p. 33; continued in the volume for 1786): Epoch 1750.

$$1249''.5 - 0''.047233\,t$$

1789. Delambre (*Tables de Jupiter et de Saturne:* Paris). The value of the inequality as given above by Laplace is repeated, except that the coefficient is stated 1249''.15.

1799. Burckhardt (*Von Zach. Allgemeine geographische Ephemeriden*, 8°, Weimar. vol. III. p. 401); Epoch 1750.

1802. Laplace (Laplace, *Méc. Cél.*, III; book VI, ch. XII, no. 33); Epoch 1750.

$$1265''.25 - 0''.0468\,t + 0''.000037\,t^2$$

1808. A. Bouvard (*Nouvelles tables de Jupiter et de Saturne:* 4°. Paris); Epoch 1800.

$$1203''.68 - 0''.0327\,t + 0''.000036\,t^2$$

1821. A. Bouvard (*Tables astronomiques contenant les tables de Jupiter;* 4°. Paris); Epoch 1800.

$$1186''.619 - 0''.03170\,t + 0''.0000334\,t^2$$

1831. Hansen (*Untersuch. der gegenseitigen Störungen des Jupiter und Saturns;* 4°. Berlin). The results of Hansen are not given in this table, since his computations are given under a different form, and the numbers will not be directly comparable.

1834. F. T. Schubert (*Traité d'Astronomie theorique;* t. III. p. 422); Epoch 1800.

$$1183''. - 0''.047108\,t + 0''.00000663\,t^2$$

1834. Pontécoulant (*Théorie analytique du Système du Monde*. t. III. p. 450; 4 vol. 8°. Paris); Epoch 1800.

$$1187''.247 - 0''.04845\,t + 0''.0000226\,t^2$$

1876. LeVerrier (*Ann. de l'Obs. de Paris*, XII. 33); Epoch 1850.

$$1205''.96 - 0''.05536\,t + 0''.00009577\,t^2 + 0''.00000000501\,t^3$$

1890. Hill (A New Theory of *Jupiter* and *Saturn*, Astron. Papers of American Ephemeris and Nautical Almanac, vol. IV, Washington. 1890). The method of Hansen is used. Dr. Hill has reduced LeVerrier's coefficient of the inequality of *Saturn* to Hansen's form, and finds it larger than his own by 36''.95.

In all these previous determinations of the great inequalities the aim has been to present them in the form

$$(A_s^{(0)} + A_s^{(1)}t + A_s^{(2)}t^2 + \dots)\sin(5l' - 2l) + (A_c^{(0)} + A_c^{(1)}t + A_c^{(2)}t^2 + \dots)\cos(5l' - 2l)$$

Some time ago Dr. G. W. Hill proposed that the inequalities be developed in a form which does not involve t in the coefficients, and suggested the method of treatment adopted in this paper. Accordingly the writer desires to record his great indebtedness to this illustrious geometer. Acknowledgements are also due Professor Stone for his interest, enthusiasm, and helpful suggestions; to Dr. T. J. J. See, for a critical examination of the manuscript; and to Mr. H. Y. Benedict, for computing some of the deviations in the last of the appended tables.

The periodic terms, that is, those depending on the mean longitudes of the planets, result from the integration of differentials of the form

$$m'Z\,{}^{\cos}_{\sin}(i'l' + il + j'\pi' + j\pi + k'\theta' + k\theta) \qquad (1)$$

where m' is the mass of the perturbing body; Z a function of the eccentricities, inclinations, and mean distances of the two planets; l, l' the mean longitudes of the planets; π, π' the longitudes of their perihelia; θ, θ' the longitudes of their nodes: i, j, k, integral numerical coefficients subject to the condition

$$i + i' + j + j' + k + k' = 0$$

The coefficient Z is of the form

$$Ae^{J}e'^{J'}\varphi^{k}\varphi'^{K'}(1 + A_1e^2 + A_2e'^2 + \dots),$$

in which the As are functions of the mean distances only; while the circular function of which it is a coefficient may be put in the form

$$\begin{aligned} &{}^{\cos}_{\sin}(j\pi + j'\pi' + k\theta + k'\theta')\cos(i'l' + il) \\ \pm\, &{}^{\sin}_{\cos}(j\pi + j'\pi' + k\theta + k'\theta')\sin(i'l' + il) \end{aligned}$$

By the integration of these equations, as effected heretofore (see Newcomb's General Integrals of Planetary Motion, *Smiths. Contrib.*, p. 281), the different elements are developed in powers of the time, and we are thus led to expressions of the form

$$(a + a't + a''t^2 + \dots)\,{}^{\cos}_{\sin}(i'l' + il)$$

Now it is well known that, if we neglect quantities of the third order with respect to the eccentricities and inclinations, the integration of the equations which give the secular variations of those elements, and of the longitudes of the perihelia and of the nodes, leads to the general expressions

$$\left.\begin{aligned} e\sin\pi &= \sum_0^n N_i\sin(g_it + \beta_i) \\ e\cos\pi &= \sum_0^n N_i\cos(g_it + \beta_i) \\ \varphi\sin\theta &= \sum_0^n M_i\sin(k_it + \delta_i) \\ \varphi\cos\theta &= \sum_0^n M_i\cos(k_it + \delta_i) \end{aligned}\right\} \qquad (2)$$

$N+1$ being the number of the planets; N_i, M_i, g_i, k_i being functions of the eccentricities at a given epoch, and of the mean distances: while β_i and δ_i are angles depending upon the positions of the perihelia and nodes at the given epoch.

If we expand (1) in terms of $e\sin\pi$, $e\cos\pi$, etc., substitute the values of $e\sin\pi$, $e\cos\pi$, etc. from (2), and integrate the resulting expressions, we come upon terms of the form

$$C\sin(i'l' + il + kt + \alpha) \qquad (3)$$

in which C and α are absolute constants, and t appears only in the argument of the sine or cosine.

A precise determination of the long-period inequalities of *Jupiter* and *Saturn* by the above substitution would be quite lengthy and more elaborate than the formula (2) will warrant. A first approximation, however, is free from these objections.

Accordingly, we may put in (2) the values of the constants N_i, g_i, β_i, M_i, etc. for the solar system as developed from the investigations of LeVerrier or Stockwell, and thus take into consideration the perturbations of all eight planets, but only to terms of the first order of the masses, since expressions (2) lose their simple form when higher powers of the masses are taken into account; and, for a more practical reason, since Stockwell's, the last, determination of the constants N_i, etc., includes only terms of the first order. It will be seen from the sequel, that when new values are given to the constants N_i, g_i, β_i, etc., so as to include higher powers of the masses, a rigorous determination of the inequalities to any degree of approximation may be readily obtained, by substitution in the forms of the approximation reached by this process.

Assuming Hill's elements of *Jupiter* and *Saturn* (*New Theory of Jupiter and Saturn*, p. 19), LeVerrier's expansion of the perturbative function in terms of the form (1) (*Ann. de l'Obs. de Paris*, t. X, pp. 37 et seq.), Stockwell's values of N_i, g_i, M_i, etc. in (2) (*Mem. on Sec. Var., Smiths. Contrib.*, p. 232), it is proposed to determine the variation of the mean longitude of *Jupiter*, and also of that of *Saturn*, to terms including the first powers of the masses, the second powers of the inclinations, and the third powers of the eccentricities.

LeVerrier's notation is used where it is not stated otherwise.

The values of the elements and masses as used by Hill are as follows (see *New Theory of Jupiter and Saturn*, pp. 19–20):

Epoch 1850, January 0d.0, Greenwich M.T.

Elements of *Jupiter*.	° ′ ″	Elements of *Saturn*.	° ′ ″
L =	159 56 26.60	L' =	14 49 34.04
π =	11 56 9.33	π' =	90 6 46.22
θ =	98 56 19.79	θ' =	112 20 49.05
φ =	1 18 42.10	φ' =	2 29 40.19
e =	0.04824277	e' =	0.05605688
n =	109256″.55563	n' =	43996″.07844

Masses of the Eight Principal Planets.

Mercury,	$m = \frac{1}{5000000}$	*Jupiter*,	$m^{\text{iv}} = \frac{1}{1047.879}$
Venus,	$m' = \frac{1}{425000}$	*Saturn*,	$m^{\text{v}} = \frac{1}{3501.6}$
Earth,	$m'' = \frac{1}{322800}$	*Uranus*,	$m^{\text{vi}} = \frac{1}{21000}$
Mars,	$m''' = \frac{1}{3093500}$	*Neptune*,	$m^{\text{vii}} = \frac{1}{19700}$

For the periodic part, $a'R_{(0,1)}$, of the perturbative function we have

$$a'R_{(0,1)} = He^h e'^{h'} \eta^f \cos(5l'-2\lambda+k'\varpi'+k\omega+u\tau')$$

where

$h = 0,1,2,3;\quad h' = 0,1,2,3;\quad f = 0,2;\quad h+h'+f = 3$

$k' = -1,-2,-3;\ k = -1,-2,-3;\ u = 0,-2;\ k'+k+u = -3$

Putting V for $5l'-2\lambda$, the following are the terms to be considered:

$$H_1\, e^3 \cos(V-3\omega) \qquad \text{(I)}$$
$$H_2\, e^2 e' \cos(V-\varpi'-2\omega) \qquad \text{(II)}$$
$$H_3\, e e'^2 \cos(V-2\varpi'-\omega) \qquad \text{(III)}$$
$$H_4\, e'^3 \cos(V-3\varpi') \qquad \text{(IV)}$$
$$H_5\, e\eta^2 \cos(V-\varpi-2\tau') \qquad \text{(V)}$$
$$H_6\, e'\eta^2 \cos(V-\omega'-2\tau') \qquad \text{(VI)}$$

where $\omega = \varpi+\tau'-\tau$.

τ and τ' are determined by means of the following formula (see *Ann. de l'Obs. de Paris*, t. X, p. 15):

$$\left.\begin{aligned}\frac{\sin\gamma\sin\tau}{\cos\varphi\cos\varphi'} &= p-p'+2\sin^2\frac{\varphi}{2}\frac{\tan\varphi'}{\cos\varphi}\sin(\theta-\theta')\cos\theta\\ \frac{\sin\gamma\cos\tau}{\cos\varphi\cos\varphi'} &= q-q'-2\sin^2\frac{\varphi}{2}\frac{\tan\varphi'}{\cos\varphi}\sin(\theta-\theta')\sin\theta\end{aligned}\right\} \quad (4)$$

together with two expressions involving τ' similar to the above, and written therefrom at once by putting $\cos\theta'$, $\sin\theta'$, φ, φ', in place of $\cos\theta$, $\sin\theta$, φ', φ, respectively.

With the assumed elements these relations give $\tau'-\tau = 23''.88$, a small quantity which may be neglected in the present discussion; an assumption that will simplify to a great extent the expanded forms of (I)–(VI).

Put

$$\begin{aligned} h &= e\sin\varpi = e\sin\omega = \sum_0^7 N_i\sin(g_it+\beta_i)\\ h' &= e'\sin\varpi' = e'\sin\omega' = \sum_0^7 N_i'\sin(g_it+\beta_i) \qquad (5)\\ u &= e\cos\varpi = e\cos\omega = \sum_0^7 N_i\cos(g_it+\beta_i)\\ u' &= e'\cos\varpi' = e'\cos\omega' = \sum_0^7 N_i'\cos(g_it+\beta_i)\end{aligned}$$

then

$$e^2 = h^2+u^2 = \overset{7}{\underset{0}{\Sigma}}{}^2 N_i\sin(g_it+\beta_i)+\overset{7}{\underset{0}{\Sigma}}{}^2 N_i\cos(g_it+\beta_i)$$

$$e'^2 = h'^2+u'^2 = \overset{7}{\underset{0}{\Sigma}}{}^2 N_i'\sin(g_it+\beta_i)+\overset{7}{\underset{0}{\Sigma}}{}^2 N_i'\cos(g_it+\beta_i)$$

Expanding and substituting from the above, we have

$$\begin{aligned} e^3\cos(V-3\omega) &= e^3(\cos3\omega\cos V+\sin3\omega\sin V)\\ &= e^3(\cos^3\omega-3\sin^2\omega\cos\omega)\cos V\\ &\qquad +e^3(3\sin\omega\cos^2\omega-\sin^3\omega)\sin V\\ &= (u^3-3h^2u)\cos V+(3hu^2-h^3)\sin V\\ &= \Big\{\overset{7}{\underset{0}{\Sigma}}{}^3 N_i\cos(g_it+\beta_i)-3\,\overset{7}{\underset{0}{\Sigma}}{}^2 N_i\sin(g_it+\beta_i)\\ &\qquad \sum_0^7 N_i\cos(g_it+\beta_i)\Big\}\cos V\\ &\quad +\Big\{3\sum_0^7 N_i\sin(g_it+\beta_i)\ \overset{7}{\underset{0}{\Sigma}}{}^2 N_i\cos(g_it+\beta_i)\\ &\qquad -\overset{7}{\underset{0}{\Sigma}}{}^3 N_i\sin(g_it+\beta_i)\Big\}\sin V\end{aligned}$$

This last form may now be expanded by means of the product

$$\left(\sum_0^n a_i\,b_i\right)\left(\sum_0^n a_i\,b_i'\right)\left(\sum_0^n a_i'\,b_i''\right)$$

which product is seen to include as particular cases.

$\overset{7}{\underset{0}{\Sigma}}{}^3 N_i\cos(g_it+\beta_i)$, $\overset{7}{\underset{0}{\Sigma}}{}^2 N_i\sin(g_it+\beta_i)$, $\sum_0^7 N_i\cos(g_it+\beta_i)$, etc.

Collecting the terms, after the expansion, the above expression assumes the following convenient form:

$$
\begin{aligned}
e^3\cos(V-3\omega) = {} & \sum_0^7 N_i^3 \cos(V-3g_it-3\beta_i) \\
& +3\sum_0^7 N_i \sum_0^7 N_j^2 \cos(V-g_{ijj}t-\beta_{ijj}) \\
& +6\sum_0^7 N_i \sum_0^7 N_j \sum_0^7 N_k \cos(V-g_{ijk}t-\beta_{ijk}),\ i\pm j\pm k
\end{aligned}
$$

where, for brevity, $g_{ijk}=g_i+g_j+g_k$, $\beta_{ijk}=\beta_i+\beta_j+\beta_k$ $N_{ijk}=N_iN_jN_k$. It should be noted that g_{2ij} in these abbreviations is equivalent to $g_2+g_i+g_j$, and not to $2g_i+g_j$: hence if the same subscript occurs more than once it should be repeated and not given as a numerical coefficient.

By writing N' in place of N in the above we have at once the transformed expression for $e'^3\cos(V-3\omega')$.

Similarly,

$$
\begin{aligned}
& e^2e'\cos(V-\varpi'-2\omega) \\
& = e^2e'[\cos(\varpi'+2\omega)\cos V+\sin(\varpi'+2\omega)\sin V] \\
& = e^2e'(2\cos^2\omega\cos\varpi'-\cos\varpi'-2\sin\omega\cos\omega\sin\varpi')\cos V \\
& \quad +e^2e'(2\cos^2\omega\sin\varpi'-\sin\varpi'+2\sin\omega\cos\omega\cos\varpi')\sin V \\
& = [2u^2u'-(h^2+u^2)u'-2huh']\cos V \\
& \quad +[2u^2h'-(h^2+u^2)h'+2huu']\sin V \\
& = (u^2u'-h^2u'-2huh')\cos V+(u^2h'-h^2h'+2huu')\sin V \\
& = \Big\{\sum_0^7{}^2 N_i\cos(g_it+\beta_i)\sum_0^7 N_i'\cos(g_it+\beta_i) \\
& \quad -\sum_0^7{}^2 N_i\sin(g_it+\beta_i)\sum_0^7 N_i'\cos(g_it+\beta_i) \\
& \quad -2\sum_0^7 N_i\sin(g_it+\beta_i)\sum_0^7 N_i\cos(g_it+\beta_i) \\
& \qquad \sum_0^7 N_i\sin(g_it+\beta_i)\Big\}\cos V \\
& \quad +\Big\{\sum_0^7{}^2 N_i\cos(g_it+\beta_i)\sum_0^7 N_i'\sin(g_it+\beta_i) \\
& \quad -\sum_0^7{}^2 N_i\sin(g_it+\beta_i)\sum_0^7 N_i'\sin(g_it+\beta_i) \\
& \quad +2\sum_0^7 N_i\sin(g_it+\beta_i)\sum_0^7 N_i\cos(g_it+\beta_i) \\
& \qquad \sum_0^7 N_i'\cos(g_it+\beta_i)\Big\}\sin V \\
& = 2\Big\{\sum_0^7 N_i'\sum_{i+1}^7 N_j\sum_{i+2}^7 N_k+\sum_0^7 N_i\sum_{i+1}^7 N_j'\sum_{i+2}^7 N_k \\
& \qquad +\sum_0^7 N_i\sum_{i+1}^7 j\sum_{i+2}^7 N_k'\Big\}\cos(V-g_{ijk}-\beta_{ijk}) \\
& \quad +\Big\{2\sum_0^7 N_iN_i'\sum_{j+1}^7 N+\sum_0^7 N_i^2\sum_{i+1}^7 N_j\Big\}\cos(V-g_{iij}-\beta_{iij}) \\
& \quad +\Big\{2\sum_0^7 N_i\sum_{i+1}^7 N_jN_j'+\sum_0^7 N_i'\sum_{i+1}^7 N_j^2\Big\}\cos(V-g_{ijj}-\beta_{ijj}) \\
& \quad +\sum_0^7 N_i^2N_i'\cos(V-g_{iii}-\beta_{iii})
\end{aligned}
$$

Omitting the Hs, (II) becomes (III) by interchanging N and N' in the above expression. It will also be noted that omitting the primes in (II) we obtain (I), and using primes throughout we obtain (IV). This is an independent check on the expansions, and might have been expected, since in the original forms (II) and (III) become (I) or (IV) according as we use primes not at all or altogether in their expressions.

It now remains to develop (V) and (VI) in a manner similar to that followed in the development of (I)–(IV).

Expanding we have

$$
\begin{aligned}
e\eta_i^2\cos(V-\omega-2\tau') & = e\eta_i^2[\cos(\omega+2\tau')\cos V+\sin(\omega+2\tau')\sin V] \\
& = e\eta_i^2(\cos\omega\cos2\tau'-\sin\omega\sin2\tau')\cos V \\
& \quad +e\eta_i^2(\sin\omega\cos2\tau'+\cos\omega\sin2\tau')\sin V \\
& = (uf-hd)\cos V+(hf+ud)\sin V
\end{aligned}
$$

where $d=\eta_i^2\sin2\tau'$, and $f=\eta_i^2\cos2\tau'$.

$$
\left.
\begin{aligned}
\text{Putting}\quad \tan\varphi\sin\theta & = p = \sum_0^7 M_i\sin(k_it+\delta_i) \\
\tan\varphi\cos\theta & = q = \sum_0^7 M_i\cos(k_it+\delta_i) \\
\tan\varphi'\sin\theta' & = p' = \sum_0^7 M_i'\sin(k_it+\delta_i) \\
\tan\varphi'\cos\theta' & = q' = \sum_0^7 M_i'\cos(k_it+\delta_i)
\end{aligned}
\right\}\qquad(6)
$$

and neglecting terms of higher order, equations (5) become

$$
\left.
\begin{aligned}
\sin\gamma\sin\tau' & = p-p' \\
\sin\gamma\cos\tau' & = q-q'
\end{aligned}
\right\}\qquad(7)
$$

$$
\begin{aligned}
\text{whence}\qquad \sin^2\gamma\sin\tau'\cos\tau' & = \tfrac{1}{2}\sin^2\gamma\sin2\tau' \\
& = 2\sin^2\tfrac{1}{2}\gamma(1-\sin^2\tfrac{1}{2}\gamma)\sin2\tau' \\
& = 2\eta_i^2(1-\eta_i^2)\sin2\tau' \\
& = (p-p')(q-q')
\end{aligned}
$$

$$
\therefore\ \eta_i^2\sin2\tau' = \frac{(p-p')(q-q')}{2(1-\eta_i^2)} = \tfrac{1}{2}(p-p')(q-q') = d
$$

In like manner

$$
\begin{aligned}
\sin^2\gamma(\cos^2\tau'-\sin^2\tau') & = (q-q')^2-(p-p')^2 \\
\text{or}\qquad 4\eta_i^2(1-\eta_i^2)\cos2\tau' & = (q-q')^2-(p-p')^2 \\
\text{whence}\qquad \eta_i^2\cos2\tau' & = \frac{(q-q')^2-(p-p')^2}{4(1-\eta_i^2)} \\
& = \tfrac{1}{4}[(q-q')^2-(p-p')^2] = f
\end{aligned}
$$

Then

$$
\begin{aligned}
d = \eta_i^2\sin2\tau' & = \tfrac{1}{2}(p-p')(q-q') \\
& = \tfrac{1}{2}\sum_0^7 W_i\sin(k_it+\delta_i)\sum_0^7 W_i\cos(k_it+\delta_i) \\
\text{and}\qquad f = \eta_i^2\cos2\tau' & = \tfrac{1}{4}\{(q-q')^2-(p-p')^2\} \\
& = \tfrac{1}{4}\left[\sum_0^7{}^2 W_i\cos(k_it+\delta_i)-\sum_0^7{}^2 W_i\sin(k_it+\delta_i)\right]
\end{aligned}
$$

where $W_i = M_i-M_i'$

whence $e\eta_i^2\cos(V-\omega-2\tau')=(uf-hd)\cos V+(hf+ud)\sin V$

$$
\begin{aligned}
& = \Big\{\tfrac{1}{4}\sum_0^7 N_i\cos(g_it+\beta_i)\left[\sum_0^7{}^2 W_i\cos(k_it+\delta_i)-\sum_0^7{}^2 W_i\sin(k_it+\delta_i)\right] \\
& \quad -\tfrac{1}{2}\sum_0^7 N_i\sin(g_it+\beta_i)\sum_0^7 W_i\sin(k_it+\delta_i)\sum_0^7 W_i\cos(k_it+\delta_i)\Big\}\cos V \\
& + \Big\{\tfrac{1}{4}\sum_0^7 N_i\sin(g_it+\beta_i)\left[\sum_0^7{}^2 W_i\cos(k_it+\delta_i)-\sum_0^7{}^2 W_i\sin(k_it+\delta_i)\right] \\
& \quad +\tfrac{1}{2}\sum_0^7 N_i\cos(g_it+\beta_i)\sum_0^7 W_i\sin(k_it+\delta_i)\sum_0^7 W_i\cos(k_it+\delta_i)\Big\}\sin V
\end{aligned}
$$

$$= \tfrac{1}{4}\left\{\sum_0^7 N_i \cos(g_i t+\beta_i)\cos V + \sum_0^7 N_i \sin(g_i t+\beta_i)\sin V\right\}\left\{\sum_0^{7}{}^2\, W_i \cos(k_i t+\delta_i) - \sum_0^{7}{}^2\, W_i \sin(k_i t+\delta_i)\right\}$$

$$-\tfrac{1}{2}\left\{\sum_0^7 N_i \sin(g_i t+\beta)\cos V - \sum_0^7 N_i \cos(g_i t+\beta_i)\sin V\right\}\left\{\sum_0^7 W_i \sin(k_i t+\delta_i)\sum_0^7 W_i \cos(k_i t+\delta_i)\right\}$$

Expanding and reducing, this last expression becomes the following, a form easily checked by comparison with the expansion of $\left(\sum_0^7 a_i b_i\right)\left(\sum_0^7 a_i b_i'\right)\left(\sum_0^7 a_i' b_i''\right)$ and convenient for the numerical computation of its several terms:

$e\eta^2 \cos(V-\omega-2\tau')$

$$\begin{aligned}
&= \tfrac{1}{2}\sum_0^7 N_i \sum_1^7 W_j \sum_2^7 W_k \cos\{V-(g_i-k_j-k_k)t-(\beta_i-\delta_j-\delta_k)\}\\
&\quad+\tfrac{1}{2}\sum_0^7 W_i \sum_1^7 N_j \sum_2^7 W_k \cos\{V-(g_j-k_i-k_k)t-(\beta_j-\delta_i-\delta_k)\}\\
&\quad+\tfrac{1}{2}\sum_0^7 W_i \sum_1^7 W_j \sum_2^7 N_k \cos\{V-(g_k-k_i-k_j)t-(\beta_k-\delta_i-\delta_j)\}\\
&\quad+\tfrac{1}{2}\sum_0^7 N_i \sum_0^7 W_i \sum_1^7 N_j \cos\{V-(g_i-k_i-k_j)t-(\beta_i-\delta_i-\delta_j)\}\\
&\quad+\tfrac{1}{4}\sum_0^7 N_i \sum_1^7 W_j^2 \cos\{V-(g_i-2k_j)t-(\beta_i-2\delta_j)\}\\
&\quad+\tfrac{1}{4}\sum_0^7 W_i^2 \sum_1^7 N_j \cos\{V-(g_j-2k_i)t-(\beta_j-2\delta_i)\}\\
&\quad+\tfrac{1}{4}\sum_0^7 W_i^2 \sum_0^7 N_i \cos\{V-(g_i-2k_i)t-(\beta_i-2\delta_i)\}
\end{aligned}$$

$e'\eta^2 \cos(V-\omega-2\tau')$ may be transformed in like manner, and the resulting expression differs from the above only in that N' takes the place of N.

(I), (II), (III), (IV), (V), (VI) have now been replaced by a series of expressions, such as

(8) $$H\Pi \cos(V-\mathrm{s}t-\textsc{d})$$

where H is the numerical factor of the perturbative function; Π a product of Ns, Ms and Ws; s a sum or difference of gs and ks; ᴅ a sum or difference of βs and δs.

It may be remarked that I, II, III and IV have the same arguments, s and ᴅ, and that VI has the same arguments as V. Hence it is possible to add the coefficients of I, II, III, and IV that correspond to the same arguments, and thus reduce the number of terms in the series to one-fourth its present magnitude. The same is true of V and VI, and the number of these terms might be reduced one-half. But in view of an independent check on the numerical work afforded by a direct comparison of the results with the integrals obtained by LeVerrier's theory (*Ann. de l'Obs. de Paris.* t. X, pp. 108, et seq.), the identity of I–VI will be preserved throughout. It will also be noted that H, Π, s, and ᴅ are constants.

In order to be as nearly as possible consistent with the notation of LeVerrier (*Ann. de l'Obs. de Paris*, t. X, p. 104), put

$$V-\mathrm{s}t-\textsc{d} = D, \qquad \frac{m'a}{\mu} = B$$

Also, let us put.

$$(a)\qquad \frac{d^2A}{dt^2} = -3\frac{m'an^2}{\mu}\frac{dR_{(0,1)}}{d\varepsilon} = +6Bn^2 H\Pi \sin D$$

$$\frac{dA}{dt} = -\frac{2m'an}{\mu}\left(a\frac{dR_{(0,1)}}{da}\right) = -2Bna\frac{dH}{da}\Pi\cos D \qquad (b)$$

$$\begin{aligned}
\frac{d\Phi}{dt} &= \tan\tfrac{1}{2}\psi\frac{dF}{dt} = +\tan\tfrac{1}{2}\psi\frac{m'an}{\mu}\cos\psi\frac{dR_{(0,1)}}{de}\\
&= +\tan\tfrac{1}{2}\psi\cos\psi\, hBn\frac{H\Pi}{\sin\psi}\cos D\\
&= \frac{\cos\psi}{1+\cos\psi}hnB\,H\Pi\cos D\\
&= hnB\,H\Pi\cos D(\tfrac{1}{2}-\tfrac{1}{8}e^2+\ldots)\\
&= \tfrac{1}{2}hnB\,H\Pi\cos D \qquad (c)
\end{aligned}$$

$$\begin{aligned}
\frac{dG}{dt} &= +\frac{m'an}{2\mu}\frac{\cos\frac{1}{2}\gamma}{\cos\psi}\frac{dR_{(0,1)}}{d\eta}\\
&= \frac{fB\cos\frac{1}{2}\gamma}{2\cos\psi}nH e\eta^{f-1}\cos D' \qquad (d)
\end{aligned}$$

$$\begin{aligned}
\frac{dT}{dt} &= -\frac{m'an}{2\mu}\frac{1}{\cos\psi\cos\frac{1}{2}\gamma}\frac{1}{\eta}\left[\frac{dR_{(0,1)}}{d\tau'}\right]\\
&= \frac{uB}{2\cos\psi\cos\frac{1}{2}\gamma}nH e\eta^{f-1}\sin D' \qquad (e)
\end{aligned}$$

in which $f = 0, 2$ and $u = 0, -2$. The D' in (d) and (e) is LeVerrier's D. These last two expressions will be taken up later and reduced to their equivalent forms.

The differential equations to be integrated for the variation of the mean longitude of *Jupiter* are

$$\frac{d^2\rho}{dt^2} = \frac{d^2A}{dt^2}$$

$$\frac{d\varepsilon}{dt} = \frac{dA}{dt}+\frac{d\Phi}{dt}+\frac{d\Psi}{dt}$$

where $\frac{d\Psi}{dt} = \tan\frac{1}{2}\varphi\sin\varphi\frac{\delta\theta}{dt}$, and $\sin\varphi\frac{\delta\theta}{dt} = G\cos(\tau-\theta) + T\sin(\tau-\theta)$, to terms of an order not higher than the third.

Integrating (a), (b), (c) we have

$$A = -\frac{6Bn^2}{(5n'-2n-\mathrm{s})^2}H\Pi\sin D$$

$$A = -\frac{2Bn}{5n'-2n-\mathrm{s}}a\frac{dH}{da}\sin D$$

$$\Phi = +\frac{hBn}{2(5n'-2n-\mathrm{s})}H\Pi\sin D$$

The integrals of (d) and (e) in their present form give rise to terms containing $e\eta$. It is necessary to transform them to corresponding forms in which $e\eta$ and $e'\eta$ are not allowed to appear. This is most conveniently done at this point, since G and T occur in $\sin\varphi\frac{\delta\theta}{dt}$, and after substitution the latter is readily reducible to an equivalent form $cH\Pi\sin D$.

It will be noticed that the numerical coefficients of the integrals of $\frac{dG}{dt}$ and $\frac{dT}{dt}$ are the same to terms of the third order, and that G contains $\sin D'$ as a factor, while T contains $\cos D'$; hence we may write

$$\Psi = \tan\tfrac{1}{2}\varphi \sin\varphi\, \delta\theta = B' \tan\tfrac{1}{2}\varphi \{G\cos(\tau-\theta) + T\sin(\tau-\theta)\}$$
$$= B' \tan\tfrac{1}{2}\varphi\, e_\eta \sin Y$$

remembering that $D' = V-\omega-2\tau$,

and putting $V-\omega-\tau-\theta = Y$

Therefore,

$$\Psi = \tfrac{1}{4}\{u[q(q-q')-p(p-p')]-h[p(q-q')+q(p-p')]\}\sin V$$
$$-\tfrac{1}{4}\{h[q(q-q')-p(p-p')]+u[p(q-q')+q(p-p')]\}\cos V$$

because of the relations (7), and the smallness of φ and γ, by virtue of which we may put $\tan\varphi = 2\tan\tfrac{1}{2}\varphi$ and $\sin\gamma = 2\sin\tfrac{1}{2}\gamma$. Substituting for p, q, h, and u their values, we have, finally, (VII)

$$\Psi = \frac{B'n}{4(5n'-2n-s)} H\left(\sum_0^7 M_i \sum_0^7 W_j \sum_0^7 N_k + \sum_0^7 W_i \sum_0^7 M_j \sum_0^7 N_k\right)$$
$$\sin\{V-(k_i+k_j+g_k)-(\delta_i+\delta_j+\rho_k)\} = \frac{Bn}{4(5n'-2n+s)} HH\sin D$$

where the H is the H of (V), and H and D are characteristic of (VII) itself. By writing N' in place of N the corresponding expression in which e'_η occurs is given; it is of the same form, and differs only in that its H is that of (VI). It will be referred to hereafter as (VIII). The symbols (VII) and (VIII) are here made to do double service — they refer to both the unintegrated and the integrated forms. This is done to save space. These insignificant terms have already taken undue space, but are essential to the completeness of the theory.

Finally, $\delta l = \delta\rho + \delta z$ $\quad\delta z = A + \Phi + \Psi$

$\delta\rho = \delta\Lambda$ $\quad\therefore\ \delta l = \delta\Lambda + A + \Phi + \Psi$

Putting $A = \Sigma L \sin D$ $\quad\Phi = \Sigma P \sin D$

$\Lambda = \Sigma C \sin D$ $\quad\Psi = \Sigma Q \sin D$

the values of the several integrals whose sum gives δl are given in the tables at the end of this paper in the columns headed L, C, etc.

To determine $\delta l'$ we have, if $B' = \frac{m\nu}{\mu'}$, $\nu = \frac{n'}{n}$ (*Ann. de l'Obs. de Paris*, t. X, p. 143),

$$n'R_{1,0} = H'e^{h}e'^{h'}\eta'\cos(5l'-2\lambda+k'\varpi'+k\omega+v\tau')$$

$$\Lambda' = \int\left(-\frac{3m'an'^2}{\mu'}\right)\frac{dR_{(1,0)}}{dl'}\,dt^2$$
$$= \frac{-15B'\nu n^2 i'}{(5n'-2n-s)^2} H'H\sin D$$

$$A' = \int\left(-\frac{2ma'^2n'}{\mu'}\right)\frac{dR_{(1,0)}}{da}\,dt$$
$$= \frac{+2B'n}{5n'-2n-s}\left(a\frac{dH'}{da}+H'\right)H\sin D$$

$$\Phi' = \tan\frac{\varphi'}{2}F' = \int\frac{ma'n'\cos\varphi'}{\mu'}\frac{dR_{(1,0)}}{de'}\,dt$$
$$= \frac{+h'B'n}{5n'-2n-s} H'H\sin D$$

$$\Psi' = \frac{B'n}{4(5n'-m-s)} H'H\sin D$$

In these expressions for A', Λ', Φ', and Ψ' the Hs, Ds, and ss are the same as those that occur in the corresponding terms of A, Λ, etc. A and A' differ only in having different Hs. The same is true of Λ and Λ', etc.

We have, as before,

$$\delta l' = A' + \Lambda' + \Phi' + \Psi'.$$

Putting $A' = \Sigma L' \sin D$ $\quad\Phi' = \Sigma P' \sin D$

$\Lambda' = \Sigma C' \sin D$ $\quad\Psi' = \Sigma Q' \sin D$

the value of $\delta l'$ may be written from the tables at the end of the paper, where under the columns headed L', C', etc., will be found the values of its several terms. The tables include all terms whose coefficients outside the sine form are equal to and greater than 0".0005.

We have now $\delta l = \Sigma C_i \sin(V-\kappa_i t-\alpha_i)$

$\delta l' = \Sigma C_i' \sin(V-\kappa_i' t-\alpha_i')$

in which the Cs, C's, κs, κ's, αs, and α's are constants, and V varies directly with the time. In general, the κ's and α's are the same as the κs and αs; but since C is to C' about as two to five, $\delta l'$ will contain more terms equal to or above any particular limiting fraction of a second of arc than δl. Hence κs and αs not found in δl will be introduced into $\delta l'$, though all angles found in δl will appear in $\delta l'$. For this reason κ and α are written with primes in the summation for $\delta l'$.

It will be noted from the tables that the inequality for *Jupiter* is represented very closely by four principal terms, and likewise the perturbation of *Saturn* by four terms corresponding severally to those of *Jupiter*. Yet, if we take only the principal terms of the above summations, the series are still too unwieldy for practical purposes. It is proposed now to put δl in the form

$$\delta l = J\sin(V'+J') + 2\Sigma C_i \cos\{V'+h_i't-\alpha_i\}\sin\tfrac{1}{2}h_i't \qquad (9)$$

and $\delta l'$ under the similar form

$$\delta l' = S\sin(V'+S') + 2\Sigma C_i'\cos\{V'+h_i't-\alpha_i'\}\sin\tfrac{1}{2}h_i't \qquad (10)$$

where the first parts $J\sin(V'+J')$, $S\sin(V'+S')$ are periodic, and represent the inequalities within less than 1" for a period of a hundred years near the epoch. Furthermore, (9) and (10) are in a very convenient form for a rigorously exact representation of the inequalities, since the summations are easily computed and readily tabulated, the deviations from the strict periodic form being slight, as $\tfrac{1}{2}(h-\kappa)$ is a small angle. In (9) and (10) J and S are absolute constants, J essentially positive, and S essentially negative; J' and S' are also constants, are nearly equal, since the ratios of the Cs to the corresponding C's, although not exactly equal to one another, are all very nearly as two to five, and $\alpha = \alpha'$, $V' = V-ht$ where h is an arbitrary constant to be so chosen that the forms resulting hereafter may be best adapted for computation; h' is a variable, and equal to $\tfrac{1}{2}(h-\kappa)$.

Putting $V' = V-ht$

we have $V-\kappa t = V'+(h-\kappa)t$

whence $\delta l = \Sigma C_i \sin[V' + (h - \kappa_i)t - \alpha_i]$

$$= \Sigma C_i \sin(V' - \alpha_i) + 2\Sigma C_i \cos[V' + \tfrac{1}{2}(h - \kappa_i)t - \alpha_i] \sin\tfrac{1}{2}(h - \kappa_i)t$$

$$\Sigma C_i \sin(V' - \alpha_i) = J \sin(V' + J')$$

if we determine J and J' by the equations

$$J \sin J' = \Sigma C_i \sin \alpha_i$$
$$J \cos J' = \Sigma C_i \cos \alpha_i$$

Hence we get

$$\delta l = J \sin(V' + J') + 2\Sigma C_i \cos\{V' + \tfrac{1}{2}(h - \kappa_i)t - \alpha_i\} \sin\tfrac{1}{2}(h - \kappa_i)t$$

If we substitute S for J, S' for J', C' for C, and α' for α, we obtain the expression for $\delta l'$.

It is obvious that h should be made equal to the κ corresponding to the largest C. The largest C corresponds to the largest C'; hence the same h should be used for both terms, $h = 67''.50927$, hence

$$V' = 1399''.77167\, t$$

The expressions of $J \sin(V' + J')$, $S \sin(V' + S')$, are

$$J \sin(V' + J') = 1160''.359 \sin(V' + 270° 12' 19''.91)$$
$$S \sin(V' + S') = -2862''.135 \sin(V' + 270° 11' 54''.76)$$

The differences between these and the true inequalities have been computed for different epochs in an interval of five thousand years, and entered in the last table.

Of the numerical data used the elements and masses have already been given. LeVerrier's values of the numerical coefficients of the perturbative function were employed, and are as follows. (See *Ann. de l'Obs. de Paris*, t. X, pp. 86–88):

	$\log H$	$\log\left(a\frac{dH}{da}\right)$	$\log\left(a\frac{dH}{da} + H\right)$
(I)	0.06578n	0.82185n	0.89202n
(II)	0.7643927	1.43806	1.52156
(III)	0.982959n	1.555067n	1.658134n
(IV)	0.719908	1.159654	1.294224
(V)(VII)	0.12390n	0.9539n	1.0138n
(VI)(VIII)	0.40780	1.1678	1.2374

Stockwell has given N_i, g_i, β_i, etc., in the form

$$N = A + \sum_0^7 B_i \mu_i, \text{ etc.}$$

and the masses in the form $\frac{1+\mu_i}{C_i}$; where A, B, and C are constants; the μs are known as soon as the masses are assumed, by equating the value of the mass to $\frac{1+\mu}{C}$ and solving for μ. The Ns, gs, etc. were obtained from Stockwell's memoir (*Smiths. Contrib.*, p. 232), the values there given being modified by the introduction of Hill's masses by means of the above formulas. The resulting values are tabulated below:

Subscript	$\log N$	$\log N'$	$\log M$	$\log M'$	$\log W$
0	n4.9095560	n4.8692317	n5.3494718	n5.4331295	4.6766936
1	5.0285713	5.0429691	5.1975562	5.3340514	n4.7649230
2	n3.9867717	n4.8369567	n4.4712917	n5.3034121	5.2342641
3	3.8388491	4.9294189	n3.3802112	n4.6669857	4.6442416
4	5.8318698	5.8823537	$-\infty$	$-\infty$	$-\infty$
5	7.3178169	7.2788245	7.1556973	7.1169562	6.0868579
6	8.6365279	8.5328158	7.3883783	6.9282268	7.2035469
7	8.1931101	n8.6841779	7.8003183	n8.1972861	8.3436915

Subscript	g	k	β	δ
	$''$	$''$	° ′ ″	° ′ ″
0	5.3916525	− 5.1489278	86 18 14.5	17 50 38.6
1	7.3942869	− 6.6302715	12 9 1.3	134 6 18.3
2	17.3885210	17.0803393	332 28 32.3	296 51 52.7
3	18.0567791	−19.1588596	136 15 28.9	254 30 21.1
4	0.6599087	0.0	72 15 0.9	106 22 29.1
5	2.7034487	− 0.7048689	108 54 41.3	21 12 25.7
6	3.7460135	− 2.9230301	28 1 4.0	133 59 48.4
7	22.5030888	−25.9744026	307 50 48.7	306 21 4.2

All terms less than $0''.0005$ have been omitted; all others included. All results have been checked by duplicate computations. The integrals for δl were first computed and checked, then those of $\delta l'$; afterwards, as a final check, those of *Saturn* were computed from those of *Jupiter* by determining the ratios of corresponding terms.

Two of the mistakes made are not without interest. A mistake in copying made N_7' positive instead of negative. As a result the inequality was reduced to one-tenth of its real value. In computing $J \sin(V + J)$ the co-named functions for the arguments of the inclination terms were taken. The resulting value of J differed less than $1''$ from its true value.

Tables I to VIII contain the integrals arising from the expressions (I) to (VIII). In the first column on the left are given as indices the products of Ns, Ms, and Ws occurring as factors in the coefficients. In table IX only one of these products is given for each argument, which serves to identify that argument. Table X contains the values of δl and $\delta l'$ in their final forms.

I. INEQUALITIES ARISING FROM $H_1 e^3 \cos(V-3\omega)$. $\delta l = \Sigma \sin(V-st-\nu)$. $\delta l' = \Sigma' \sin(V-st-\nu)$.

	L	C	P	L'	C'	Σ	Σ'	s	ν
	″		″	″	″	″	″	″	° ′ ″
N_5^3	— 0.011	0.000	0.000	+ 0.028	0.000	— 0.011	+ 0.028	8.11035	326 44 3.9
N_6^3	—102.158	+2.595	— .341	+251.697	—7.533	—100.204	+247.164	11.23801	84 3 12.0
N_7^3	— 5.182	+0.126	— .017	+ 12.883	—0.366	— 5.073	+ 12.517	67.50927	203 32 26.1
$N N_6^2$	+ 0.058	— .001	.099	— 0.144	+ .004	+ 0.057	— 0.140	12.88668	142 20 22.5
$N N_7^2$	+ .008	.000	.000	— .020	+ .001	+ .008	— .019	50.40083	341 59 51.9
$N_1 N_6^2$	— .076	+ .002	.000	+ .189	— .006	— .074	+ .183	14.88631	69 11 9.3
$N_1 N_7^2$	— .010	.000	.000	+ .026	— .001	— .010	+ .025	52.40046	267 50 38.7
$N_2 N_6^2$	+ .007	.000	.000	— .017	+ .001	+ .007	— .016	21.88055	28 30 40.3
$N_2 N_7^2$	+ .001	.000	.000	— .002	.000	+ .001	— .002	62.39470	228 10 9.7
$N_3 N_6^2$	— .005	.000	.000	+ .012	.000	— .005	+ .012	25.54881	192 17 36.9
$N_3 N_7^2$	— .001	.000	.000	+ .002	.000	— .001	+ .002	63.06295	31 57 6.3
$N_4 N_5^2$	— .001	.000	000	+ 0.003	.000	— .001	+ 0.003	6.06680	290 4 23.5
$N_4 N_6^2$	— .481	+ .012	— .002	+ 1.193	— .035	— .471	+ 1.158	8.15194	128 17 8.9
$N_4 N_7^2$	— 0.066	+ .002	.000	+ 0.163	—0.004	— 0.064	+ 0.159	45.66669	327 56 38.3
$N_5 N_6^2$	— 11.731	+ .374	— .049	+ 36.627	—1.084	— 14.409	+ 35.543	10.19548	164 56 49.3
$N_5 N_7^2$	— 2.014	+0.050	— .006	+ 5.008	—0.144	— 1.970	+ 4.864	47.79963	4 36 18.7
$N_6 N_7^2$	— 42.025	+1.037	— .136	+104.468	—3.010	— 41.124	+101.458	48.75219	283 42 41.4
$N_4^2 N_6$	+ 0.001	0.000	.000	+ 0.002	.000	+ 0.001	+ 0.002	5.06583	172 31 5.8
$N_4^2 N_7$	.000	.000	.000	+ 0.001	.000	.000	+ 0.001	23.82291	92 20 50.5
$N_5^2 N_6$	+ .706	— .018	+ .002	+ 1.766	— .052	— .690	+ 1.714	9.15291	245 50 26.6
$N_5^2 N_7$	— 0.261	+0.006	— .001	+ 0.649	—0.019	— 0.256	+ 0.630	27.90999	165 40 11.3
$N_6^2 N_7$	—113.635	+2.812	— .374	+282.481	—8.247	—111.167	+274.234	29.99512	3 52 56.7
$N N_5 N_6$	+ 0.006	0.000	.000	— 0.014	0.000	+ 0.006	— 0.014	11.84411	223 13 59.8
$N N_5 N_7$	+ .002	.000	.000	— .005	.000	+ .002	— .005	30.60119	143 3 41.5
$N N_6 N_7$	+ .013	— .001	.000	— .106	+ .003	+ .012	— .103	31.61375	62 10 7.2
$N_1 N_4 N_6$	.000	.000	.000	+ .001	.000	.000	+ .001	11.80021	112 25 6.2
$N_1 N_5 N_6$	— .007	.000	.000	+ .018	— .001	— .007	+ .017	13.84375	149 4 46.6
$N_1 N_5 N_7$	— .003	.000	.000	+ .007	.000	— .003	+ .007	32.60082	68 54 31.3
$N_1 N_6 N_7$	— .056	+ .001	.000	+ .140	— .004	— .055	+ .136	33.64339	348 0 54.0
$N_2 N_5 N_6$	+ .001	.000	.000	— .002	.000	+ .001	-- .002	23.83798	109 24 17.6
$N_2 N_5 N_7$	.000	.000	.000	— .001	.000	.000	— .001	42.59506	29 14 2.3
$N_2 N_6 N_7$	+ .005	.000	.000	— .013	.000	+ .005	— .013	43.63762	308 20 25.0
$N_3 N_5 N_6$	.000	.000	.000	+ .001	.000	.000	+ .001	24.50624	273 11 14.2
$N_3 N_6 N_7$	— .004	.000	.000	+ .009	.000	— .004	+ .009	44.30588	112 7 31.6
$N_4 N_5 N_6$	— .016	+ .001	.000	+ .114	— .003	— .015	+ .111	7.10937	209 10 45.2
$N_4 N_5 N_7$	— .017	.000	.000	+ .042	— .001	— .017	+ .041	25.86645	129 0 30.9
$N_4 N_6 N_7$	— 0.355	+ .009	— .001	+ 0.882	— .026	— 0.347	+ 0.856	26.90901	48 6 53.6
$N_5 N_6 N_7$	— 10.891	+0.273	—0.036	+ 27.074	—0.791	— 10.654	+ 26.283	28.75255	84 46 34.0

II. INEQUALITIES ARISING FROM $H_4 e^2 e' \cos(V-\varpi'-2\omega)$.

	L	C	P	L'	C'	P'	Σ	Σ'	s	ν
	″	″	″	″	″	″	″	″	″	° ′ ″
$N_5^2 N_5'$	+ 0.052	— 0.001	0.000	— 0.128	+ 0.003	0.000	+ 0.051	— 0.125	8.11035	326 44 3.9
$N_6^2 N_6'$	+103.132	— 8.417	+ .896	—1002.132	+25.281	+1.106	+395.581	—975.744	11.23804	84 3 12.0
$N_7^2 N_7'$	— 80.206	+ 1.626	—0.171	+ 199.381	— 4.836	—0.211	— 78.751	+194.331	67.50927	203 32 26.1
$N N_5 N_5'$	0.000	0.000	.000	+ 0.001	0.000	.000				
$N' N_5^2$	.000	.000	.000	+ .001	.000	.000	0.000	+ 0.002	10.80155	304 7 37.1
$N N_6 N_6'$	— .152	+ .003	.000	+ .377	— .009	.000				
$N' N_6^2$	— .088	+ .002	.000	+ .218	— .605	.000	— .235	+ .583	12.88668	142 20 22.5
$N N_7 N_7'$	+ .081	— .002	.000	— .203	+ .005	.000				
$N' N_7^2$	— .012	.000	.000	+ .030	— .001	.000	+ .067	— .169	50.40083	341 59 51.9
$N_1 N_5 N_5'$	+ .001	.000	.000	— .001	.000	.000				
$N_1' N_5^2$	.000	.000	.000	— .001	.000	.000	+ .001	— .002	12.80118	229 58 23.9
$N_1 N_6 N_6'$	+ .200	— .004	.000	— .497	+ .012	+0.001				
$N_1' N_6^2$	+ .131	— .003	.000	— .326	+ .008	.000	+ .324	— .802	14.88631	69 11 9.3
$N_1 N_7 N_7'$	— .108	+ .002	.000	+ .268	— .007	.000				
$N_1' N_7^2$	+ .018	.000	.000	— .045	+ .001	.000	— .088	+ .217	52.40046	267 50 38.7
$N_2 N_6 N_6'$	— .018	.000	.000	+ .046	— .001	.000				
$N_2' N_6^2$	— 0.083	+ 0.002	0.000	+ 0.206	— 0.005	0.000	— 0.099	+ 0.246	24.88055	28 30 40.3

	L	C	P	L′	C′	P′	Σ	Σ′	S	D
	″	″	″	″	″	″	″	″	″	° ′ ″
$N_2 N_7 N_7'$	+ 0.010	0.000	0.000	— 0.025	+ 0.001	0.000				
$N_2' N_7^2$	— .011	.000	.000	+ .028	— .001	.000	— 0.001	+ 0.003	62.39470	228 10 0.7
$N_3 N_6 N_6'$	+ .013	.000	.000	— .033	+ .001	.000				
$N_3' N_6^2$	+ .103	— .002	.000	— .255	+ .006	.000	+ .114	— .281	25.54881	192 17 36.9
$N_3 N_7 N_7'$	— .007	.000	.000	+ .018	.000	.000				
$N_3' N_7^2$	+ .014	.000	.000	— .035	+ .001	.000	+ .007	— .016	63.06296	31 57 6.3
$N_4 N_5 N_5'$	+ .003	.000	.000	— .008	.000	.000				
$N_4' N_5^2$	+ 0.002	.000	.000	— 0.005	.000	.000	+ 0.005	— 0.013	6.06680	290 4 23.5
$N_4 N_6 N_6'$	+ 1.260	— .026	+ .003	— 3.129	+ .079	+ .004				
$N_4' N_6^2$	+ 0.898	— .019	+ .002	— 2.232	+ .056	+ .002	+ 2.118	— 5.220	8.15194	128 17 8.9
$N_4 N_7 N_7'$	— .677	+ .014	— .001	+ 1.683	— .012	.000				
$N_4' N_7^2$	+ 0.123	— .003	.000	— 0.305	+ 0.008	+ .106	— 0.544	+ 1.343	45.66609	327 56 38.3
$N_5 N_6 N_6'$	+ 38.650	— .810	+ .086	— 96.077	+ 2.426	+ .062				
$N_5' N_6^2$	+ 22.430	— .470	+ .050	— 55.759	+ 1.408	— .056	+ 59.936	—147.834	10.19548	164 56 49.3
$N_5 N_7 N_7'$	— 20.785	+ .425	— .015	+ 51.668	— 1.273	+0.008				
$N_5' N_7^2$	+ 3.067	— 0.063	+ .006	— 7.622	+ 0.188	—1.158	— 17.395	+ 42.913	47.70963	4 36 18.7
$N_6 N_7 N_7'$	—433.605	+ 8.852	— .938	+1077.883	—26.492	+0.147				
$N_6' N_7^2$	+ 55.117	— 1.125	+ .119	— 137.013	+ 3.368	.000	—371.580	+916.735	48.75219	283 42 41.4
$N_4 N_4' N_6$	+ 0.003	0.000	.000	— 0.007	0.000	.000				
$N_4^2 N_6'$	+ .001	.000	.000	— .002	.000	.000	+ 0.004	— 0.009	5.06583	172 31 5.8
$N_4 N_4' N_7$	+ .001	.000	.000	— .003	.000	.000				
$N_4^2 N_7'$	— 0.001	.000	.000	+ 0.004	.000	.000	0.000	+ 0.001	23.82291	92 20 50.5
$N_5 N_5' N_6$	+ 2.150	— 0.045	+ .005	— 5 346	+ .135	+ .006				
$N_5^2 N_6'$	+ 0.926	— .019	+ .002	— 2.303	+ .058	+ .003	+ 3.019	— 7.447	9.15291	245 50 26.6
$N_5 N_5' N_7$	+ 0.795	— .016	+ .002	— 1.976	+ .049	+ .002				
$N_5^2 N_7'$	— 1.347	+ 0.028	— .003	+ 3.348	— .084	— .004	— 0.541	+ 1.335	27.90999	165 40 11.3
$N_6 N_6' N_7$	+298.073	— 6.174	+0.656	— 740.975	+18.452	+0.771				
$N_6^2 N_7'$	—586.236	+12.126	—1.285	+1457.303	—36.290	—1.516	—282.840	+697.745	29.99512	3 52 56.7
$N' N_4 N_6$	0.000	0.000	0.000	+ 0.001	0.000	.000				
$N N_4' N_6$	.000	.000	.000	+ .001	.000	.000				
$N N_4 N_6'$	.000	.000	.000	+ .001	.000	.000	0.000	+ 0.003	9.80057	186 34 19.4
$N' N_4 N_7$	.000	.000	.000	.000	.000	.000				
$N N_4' N_7$	.000	.000	.000	.000	.000	.000				
$N N_4 N_7'$	.000	.000	.000	— .001	.000	.000	.000	— .001	28.55765	106 24 4.1
$N' N_5 N_6$	— .008	.000	.000	+ .021	— .001	.000				
$N N_5' N_6$	— .008	.000	.000	+ .021	— .001	.000				
$N N_5 N_6'$	— .007	.000	.000	+ .018	.000	.000	— .023	+ .058	11.84411	223 13 59.8
$N' N_5 N_7$	— .003	.000	.000	+ .008	.000	.000				
$N N_5' N_7$	— .003	.000	.000	+ .008	.000	.000				
$N N_5 N_7'$	+ .010	.000	.000	— .026	+ .001	.000	+ .004	— .009	30.60119	143 3 44.5
$N' N_6 N_7$	— .065	+ .001	.000	+ .161	— .004	.000				
$N N_6' N_7$	— .056	+ .001	.000	+ .139	— .003	.000				
$N N_6 N_7'$	+ .220	— .004	.000	— .548	+ .014	.000	+ .097	— .241	31.64375	62 10 7.2
$N_1' N_4 N_6$	.000	.000	.000	— .001	.000	.000				
$N_1 N_4' N_6$	.000	.000	.000	— .001	.000	.000				
$N_1 N_4 N_6'$	.000	.000	.000	— .001	.000	.000	.000	— .003	11.80021	112 25 6.2
$N_1' N_4 N_7$	.000	.000	.000	.000	.000	.000				
$N_1 N_4' N_7$	.000	.000	.000	.000	.000	.000				
$N_1 N_4 N_7'$	.000	.000	.000	+ .001	.000	.000	.000	+ .001	30.55728	32 14 50.9
$N_1' N_5 N_6$	+ .013	.000	.000	— .031	+ .001	.000				
$N_1 N_5' N_6$	+ .011	.000	.000	— .028	+ .001	.000				
$N_1 N_5 N_6'$	+ .010	.000	.000	— .024	+ .001	.000	+ .034	— .080	13.84375	149 4 46.6
$N_1' N_5 N_7$	+ .005	.000	.000	— .012	.000	.000				
$N_1 N_5' N_7$	+ .004	.000	.000	— .010	.000	.000				
$N_1 N_5 N_7'$	— .014	.000	.000	+ .034	— .001	.000	— .005	+ .011	32.60082	68 54 31.3
$N_1' N_6 N_7$	+ .097	— .002	.000	— .241	+ .006	.000				
$N_1 N_6' N_7$	+ .074	— .002	.000	— .184	+ .004	.000				
$N_1 N_6 N_7'$	— .291	+ .006	.000	+ .723	— .018	— .001	— .118	+ .289	33.64339	348 0 54.0
$N_2' N_5 N_6$	— .008	.000	.000	+ .020	— .001	.000				
$N_2 N_5' N_6$	— .001	.000	.000	+ .002	.000	.000				
$N_2 N_5 N_6'$	— .001	.000	.000	+ .002	.000	.000	— 0.010	+ 0.023	23.83798	109 24 17.6
$N_2' N_5 N_7$	— 0.003	0.000	0.000	+ 0.007	0.000	0.000				

	L	C	P	L'	C'	P'	Σ	Σ'	s	D
	″	″	″	″	″	″	″	″	″	° ′ ″
$N_2N_5'N_7$	0.000	0.000	0.000	+ 0.001	0.000	0.000				
$N_2N_5N_7'$	+ .001	.000	.000	— .003	.000	.000	— 0.002	+ 0.005	42.59506	29 14 2.3
$N_2'N_6N_7$	— .061	+ .001	.000	+ .152	— .004	.000				
$N_2N_6'N_7$	— .007	.000	.000	+ .017	.000	.000				
$N_2N_6N_7'$	+ .027	— .001	.000	— .066	+ .002	.000	— .041	+ .101	43.63762	308 20 25.0
$N_3'N_5N_6$	+ .010	.000	.000	— .024	+ .001	.000				
$N_3N_5'N_6$	+ .001	.000	.000	— .002	.000	.000				
$N_3N_5N_6'$	+ .001	.000	.000	— .002	.000	.000	+ 0.12	— .027	21.50621	273 11 14.2
$N_3'N_5N_7$	+ .004	.000	.000	— .009	.000	.000				
$N_3N_5'N_7$	.000	.000	.000	— .001	.000	.000				
$N_3N_5N_7'$	— .001	.000	.000	+ .002	.000	.000	+ .003	— .008	43.26332	193 0 58.9
$N_3'N_6N_7$	+ .076	— .001	.000	— .188	+ .005	.000				
$N_3N_6'N_7$	+ .005	.000	.000	— .012	.000	.000				
$N_3N_6N_7'$	— .019	.000	.000	+ .047	— .001	.000	+ .061	— .149	44.30588	112 7 31.6
$N_4'N_5N_6$	+ .086	— .002	.000	— .214	+ .006	.000				
$N_4N_5'N_6$	+ .070	— .001	.000	— .174	+ .005	.000				
$N_4N_5N_6'$	+ .060	— .001	.000	— .150	+ .004	.000	+ .202	— .523	7.10937	209 10 45.2
$N_4'N_5N_7$	+ .032	— .001	.000	— .079	+ .002	.000				
$N_4N_5'N_7$	+ .026	— .001	.000	— .064	+ .002	.000				
$N_4N_5N_7'$	— .088	+ .002	.000	+ 0.218	— .005	.000	— .030	+ 0.074	25.86645	129 0 30.9
$N_4'N_6N_7$	+ .664	— .014	+ .001	— 1.650	+ .041	+ .002				
$N_4N_6'N_7$	+ 0.465	— .010	+ .001	— 1.157	+ .029	+ .001				
$N_4N_6N_7'$	— 1.830	+ .038	— .001	+ 4.550	— 0.114	— .005	— .689	+ 1.696	26.90901	48 6 53.6
$N_5'N_6N_7$	+ 16.579	— .343	+ .036	— 41.215	+ 1.033	+ .045				
$N_5N_6'N_7$	+ 14.282	— 0.296	+ .031	— 35.509	+ 0.885	+ .039				
$N_5N_6N_7'$	— 56.187	+ 1.163	—0.123	+ 139.675	— 3.481	—0.152	— 24.858	+ 61.320	28.75225	84 46 34.0

III. INEQUALITIES ARISING FROM $H_3ee'^2\cos(V-2\varpi'-\omega)$.

	L	C	P	L'	C'	P'	Σ	Σ'	s	D
	″	″	″	″	″	″	″	″	″	° ′ ″
$N_5'^2N_5$	— 0.078	+ 0.001	0.000	+ 0.194	— 0.004	0.000	— 0.077	+ 0.190	8.11035	326 44 3.9
$N_6'^2N_6$	— 525.172	+ 8.710	— .583	+1305.507	—27.268	—2.880	— 517.045	+1275.359	11.23804	84 3 12.0
$N_7'^2N_7$	— 411.000	+ 6.553	— .438	+1021.691	—20.515	—2.167	— 404.885	+ 999.009	67.50927	203 32 26.1
$N'N_5N_5'$	0.000	0.000	.000	— 0.002	0.000	0.000				
$NN_5'^2$	.000	.000	.000	— .001	.000	.000	0.000	— 0.003	10.80155	304 7 37.1
$N'N_6N_6'$	+ .228	— .004	.000	— .568	+ .012	+ .001				
$NN_6'^2$	+ .099	— .002	.000	— .245	+ .005	+ .001	+ .321	— .794	12.88668	142 20 22.5
$N'N_7N_7'$	— .123	+ .002	.000	+ .305	— .006	— .001				
$NN_7'^2$	+ .209	— .003	.000	— .519	+ .011	+ .001	+ .085	— .209	50.40083	341 59 51.9
$N_1'N_5N_5'$	— .001	.000	.000	+ .002	.000	.000				
$N_1N_5'^2$	.000	.000	.000	+ .001	.000	.000	— .001	+ 0.003	12.80118	229 58 23.9
$N_1'N_6N_6'$	— .342	+ .006	— .001	+ .849	— .018	— .002				
$N_1N_6'^2$	— .130	+ .002	.000	+ .324	— .007	— .001	— .465	+ 1.145	14.88631	69 11 9.3
$N_1'N_7N_7'$	+ .185	— .003	.000	— .459	+ .009	+ .001				
$N_1N_7'^2$	— .277	+ .004	.000	+ .688	— .014	— .001	— .091	+ 0.224	52.40046	267 50 38.7
$N_2'N_5N_5'$	+ .001	.000	.000	— .001	.000	.000				
$N_2N_5'^2$	.000	.000	.000	.000	.000	.000	+ .001	— .001	22.79542	190 17 54.9
$N_2'N_6N_6'$	+ .216	— .004	.000	— .536	+ .011	+ .001				
$N_2N_6'^2$	+ .012	.000	.000	— .030	+ .001	.000	+ .224	— .553	21.88055	28 30 40.3
$N_2'N_7N_7'$	— .116	+ .002	.000	+ .288	— .006	— .001				
$N_2N_7'^2$	+ .025	.000	.000	— .063	+ .001	.000	— .089	+ .219	62.39470	228 10 0.7
$N_3'N_5N_5'$	+ .001	.000	.000	+ .002	.000	.000				
$N_3N_5'^2$	.000	.000	.000	.000	.000	.000	+ .001	+ .002	23.46368	354 4 51.5
$N_3'N_6N_6'$	— .267	+ .004	.000	+ .664	— .014	— .001				
$N_3N_6'^2$	— .009	.000	.000	+ .021	.000	.000	— .272	+ .670	25.54881	192 17 36.9
$N_3'N_7N_7'$	+ .143	— .002	.000	— .357	+ .007	+ .001				
$N_3N_7'^2$	— .018	.000	.000	+ .045	— .001	.000	+ .123	— .305	63.06296	31 57 6.3
$N_4'N_5N_5'$	— .006	.000	.000	+ .016	.000	.000				
$N_4N_5'^2$	— 0.003	.000	.000	+ 0.006	.000	.000	— 0.009	+ 0.022	6.06680	290 4 23.5
$N_4'N_6N_6'$	— 2.339	+ .039	— .005	+ 5.813	— .122	— .013				
$N_4N_6'^2$	— 0.820	+ 0.013	—0.002	+ 2.038	— 0.043	—0.005	— 3.111	+ 7.668	8.15194	128 17 8.9

	L	C	P	L'	C'	P'	Σ	Σ′	S	D
	″	″	″	″	″	″	″	″	″	° ′ ″
$N_4'N_7N_7'$	+ 1.258	— 0.020	+0.003	— 3.127	+ 0.064	+0.007				
$N_4N_7'^2$	— 1.734	+ .028	— .004	+ 4.311	— 0.088	— .009	— 0.469	+ 1.158	45.66609	327 56 38.3
$N_5'N_6N_6'$	— 58.441	+ .970	— .065	+ 145.277	— 3.037	— .319				
$N_5N_6'^2$	— 25.175	+ .418	— .028	+ 62.581	— 1.308	— .139	— 82.321	+ 203.055	10.19548	164 56 49.3
$N_5'N_7N_7'$	+ 31.428	— .508	+ .031	— 78.126	+ 1.591	+ .168				
$N_5N_7'^2$	— 53.254	+ 0.861	— .058	+ 132.382	— 2.696	—0.285	— 21.497	+ 53.034	47.70963	11 36 18.7
$N_6'N_7N_7'$	+ 564.870	— 9.126	+0.611	—1404.189	+28.573	+3.019				
$N_6N_7'^2$	—1110.959	+17.951	—1.202	+2761.694	—56.197	—5.936	— 537.855	+1326.964	48.75219	283 42 41.4
$N_4'N_4N_6'$	— 0.004	0.000	0.000	+ 0.009	0.000	0.000				
$N_4'^2N_6$	— .003	.000	.000	+ .006	.000	.000	— 0.007	+ 0.015	5.06583	172 31 5.8
$N_4N_4'N_7$	+ .005	.000	.000	— .013	.000	.000				
$N_4'^2N_7$	— 0.001	.000	.000	+ 0.002	.000	.000	+ 0.004	— 0.011	23.82291	92 20 50.5
$N_5'N_5N_6'$	— 2.801	+ .017	— .006	+ 6.964	— .145	— .015				
$N_5'^2N_6$	— 1.626	+ .027	— .004	+ 4.041	— .084	— .009	— 4.363	+ 10.752	9.15291	245 50 26.6
$N_5'N_5N_7'$	+ 4.074	— .067	+ .009	— 10.127	+ .209	+ .022				
$N_5'^2N_7$	— 0.601	+ 0.009	—0.001	+ 1.494	— 0.031	—0.003	+ 3.423	— 8.436	27.90999	165 40 11.3
$N_6'N_6N_7'$	+1527.412	—25.006	+1.674	—3796.938	+78.285	+8.270				
$N_6'^2N_7$	— 194.155	+ 3.179	—0.213	+ 482.641	— 9.951	—1.051	+1312.891	—3238.744	29.99512	3 52 56.7
$NN_4'N_6'$	0.000	— 0.000	.000	— 0.001	0.000	0.000				
$N'N_4N_6'$	.000	.000	.000	— .001	.000	.000				
$N'N_4'N_6$	+ .001	.000	.000	— .001	.000	.000	+ 0.001	— 0.003	9.80057	186 31 19.4
$NN_4'N_7'$	— .001	.000	.000	+ .002	.000	.000				
$N'N_4N_7'$	.000	.000	.000	+ .001	.000	.000				
$N'N_4'N_7$	.000	.000	.000	.000	.000	.000	— .001	+ .003	28.55765	106 24 4.1
$NN_5'N_6'$	+ .011	.000	.000	— .027	+ .001	.000				
$N'N_5N_6'$	+ .011	.000	.000	— .027	+ .001	.000				
$N'N_5'N_6$	+ .013	.000	.000	— .032	+ .001	.000	+ .035	— .083	11.84411	223 13 59.8
$NN_5'N_7'$	— .016	.000	.000	+ .040	— .001	.000				
$N'N_5N_7'$	— .016	.000	.000	+ .040	— .001	.000				
$N'N_5'N_7$	+ .005	.000	.000	— .011	.000	.000	— .027	+ 0.067	30.60119	143 3 44.5
$NN_6'N_7'$	— .287	+ .004	.000	+ .713	— .015	— .002				
$N'N_6N_7'$	— .332	+ .005	.000	+ .826	— .017	— .002				
$N'N_6'N_7$	+ .084	— .001	.000	— .210	+ .004	.000	— .527	+ 1.299	31.64375	62 10 7.2
$N_1N_4'N_6'$	— .001	.000	.000	+ .001	.000	.000				
$N_1'N_4N_6'$	— .001	.000	.000	+ .001	.000	.000				
$N_1'N_4'N_6$	— .001	.000	.000	+ .002	.000	.000	— .003	+ 0.004	11.80021	112 25 6.2
$N_1N_4'N_7'$	+ .001	.000	.000	— .002	.000	.000				
$N_1'N_4N_7'$	+ .001	.000	.000	— .002	.000	.000				
$N_1'N_4'N_7$	.000	.000	.000	+ .001	.000	.000	+ .002	— .003	30.55728	32 14 50.9
$N_1N_5'N_6'$	— .014	.000	.000	+ .036	— .001	.000				
$N_1'N_5N_6'$	— .016	.000	.000	+ .041	— .001	.000				
$N_1'N_5'N_6$	— .019	.000	.000	+ .047	— .001	.000	— .049	+ .121	13.84375	149 4 46.6
$N_1N_5'N_7'$	+ .021	.000	.000	— .052	+ .001	.000				
$N_1'N_5N_7'$	+ .024	.000	.000	— .059	+ .001	.000				
$N_1'N_5'N_7$	— .007	.000	.000	+ .018	.000	.000	+ .038	— 0.091	32.60082	68 54 31.3
$N_1N_6'N_7'$	+ .378	— .006	.000	— 0.941	+ .019	+ .002				
$N_1'N_6N_7'$	+ .497	— .008	+ .001	— 1.235	+ .025	+ .003				
$N_1'N_6'N_7$	— .126	+ .002	.000	+ 0.314	— .006	— .001	+ .738	— 1.820	33.64339	348 0 54.0
$N_2N_4'N_7'$	.000	.000	.000	.000	.000	.000				
$N_2'N_4N_7'$	.000	.000	.000	+ .001	.000	.000				
$N_2'N_4'N_7$	.000	.000	.000	.000	.000	.000	.000	+ 0.001	40.55152	352 34 21.9
$N_2N_5'N_6'$	+ .001	.000	.000	— .003	.000	.000				
$N_2'N_5N_6'$	+ .010	.000	.000	— .026	+ .001	.000				
$N_2'N_5'N_6$	+ .012	.000	.000	— .030	+ .001	.000	+ .023	— .057	23.83798	109 24 17.6
$N_2N_5'N_7'$	— .002	.000	.000	+ .005	.000	.000				
$N_2'N_5N_7'$	— .015	.000	.000	+ .037	— .001	.000				
$N_2'N_5'N_7$	+ .004	.000	.000	— .011	.000	.000	— ,013	+ .030	42.59506	29 14 2.3
$N_2N_6'N_7'$	— .035	+ .001	.000	+ .087	— .002	0.000				
$N_2'N_6N_7'$	— .314	+ .005	.000	+ .780	— .016	— .002				
$N_2'N_6'N_7$	+ .080	— .001	.000	— .198	+ .004	.000	—0.264	+ 0.653	43.63762	308 20 25.0
$N_3N_4'N_7'$	.000	.000	.000	.000	.000	.000				
$N_3'N_4N_7'$	0.000	0.000	0.000	— 0.001	.000	0.000				

	L	C	P	L'	C'	P'	Σ	Σ'	s	D
	″	″	″	″	″	″	″	″	″	° ′ ″
$N_3'N_4'N_7$	0.000	0.000	0.000	+ 0.001	0.000	0.000	0.000	0.000	41.21978	156 21 18.5
$N_3N_5'N_6'$	− .001	.000	.000	+ .002	.000	.000				
$N_3'N_5N_6'$	− .013	.000	.000	+ .032	− .001	.000				
$N_3'N_5'N_6$	− .015	.000	.000	+ .037	− .001	.000	− .029	+ .069	24.50624	273 11 14.2
$N_3N_5'N_7'$	+ .001	.000	.000	− .003	.000	.000				
$N_3'N_5N_7'$	+ .019	.000	.000	− .046	+ .001	.000				
$N_3'N_5'N_7$	− .005	.000	.000	+ .014	.000	.000	+ .015	− .034	43.26332	193 0 58.9
$N_3N_6'N_7'$	+ .025	.000	.000	− .062	+ .001	.000				
$N_3'N_6N_7'$	+ .388	− .006	.000	− .965	+ .019	+ .002				
$N_3'N_6'N_7$	− .099	+ .002	.000	+ .245	− .005	− .001	+ .310	− .766	44.30588	112 7 31.6
$N_4N_5'N_6'$	− .091	+ .001	.000	+ .227	− .004	− .001				
$N_4'N_5N_6'$	− .112	+ .002	.000	+ .279	− .006	− .001				
$N_4'N_5'N_6$	− .130	+ .002	.000	+ .324	− .007	− .001	− .328	+ .811	7.10937	209 10 45.2
$N_4N_5'N_7'$	+ .133	− .002	.000	− .330	+ .007	+ .001				
$N_4'N_5N_7'$	+ .163	− .003	.000	− .405	+ .008	+ .001				
$N_4'N_5'N_7$	− 0.048	+ .001	.000	+ 0.119	− .002	.000	+ 0.244	− 0.601	25.86645	129 0 30.9
$N_4N_6'N_7'$	+ 2.384	− .039	+ .003	− 5.928	+ .122	+ .013				
$N_4'N_6N_7'$	+ 3.401	− .056	+ .004	− 8.455	+ .175	+ .018				
$N_4'N_6'N_7$	− 0.865	+ 0.014	− .001	+ 2.149	− 0.014	− .006	+ 4.845	− 11.956	26.90901	48 6 53.6
$N_5N_6'N_7'$	+ 73.197	− 1.199	+ .080	− 181.958	+ 3.755	+ .397				
$N_5'N_6N_7'$	+ 84.960	− 1.392	+ .093	− 211.199	+ 4.358	+ .160				
$N_5'N_6'N_7$	− 21.599	+ 0.354	−0.019	+ 53.692	− 1.108	−0.117	+ 134.475	− 331.720	28.75255	84 46 34.0

IV. INEQUALITIES ARISING FROM $H_4 e'^3 \cos(V-3\omega')$.

	L	C	L'	C'	P'	Σ	Σ'	s	D
	″	″	″	″	″	″	″	″	° ′ ″
$N_5'^3$	+ 0.039	0.000	− 0.097	+ 0.002	0.000	+ 0.039	− 0.095	8.11035	326 44 3.9
$N_6'^3$	+ 225.703	− 2.760	− 561.068	+ 9.290	+ 1.857	+ 222.943	− 549.921	11.23804	84 3 12.0
$N_7'^3$	− 694.800	+ 8.172	+1727.175	−27.494	− 5.495	− 686.628	+1694.186	67.50927	203 32 26.1
$N'N_5'^2$	0.000	0.000	+ 0.001	0.000	0.000	0.000	+ 0.001	10.80155	304 7 37.1
$N'N_6'^2$	− .147	+ .002	+ .366	− .006	− .001	− .145	+ .359	12.88668	142 20 22.5
$N'N_7'^2$	− .311	+ .001	+ .775	− .012	− .002	− .307	+ .761	50.40083	341 59 51.9
$N_1'N_5'^2$	+ .001	.000	− .002	.000	.000	+ .001	− .002	12.80118	229 58 23.9
$N_1'N_6'^2$	+ .220	− .003	− 0.548	+ .009	+ .002	+ .217	− 0.537	14.88631	69 11 9.3
$N_1'N_7'^2$	+ .468	− .005	− 1.164	+ .019	+ .004	+ .463	− 1.141	52.40046	267 50 38.7
$N_2'N_5'^2$	.000	.000	+ 0.001	.000	.000	.000	+ 0.001	22.79542	190 17 54.9
$N_2'N_6'^2$	− .139	+ .002	+ .345	− .006	− .001	− .137	+ .338	24.88055	28 30 40.3
$N_2'N_7'^2$	− .294	+ .001	+ .731	− .012	− .002	− .290	+ .717	62.39470	228 10 0.7
$N_3'N_5'^2$	.000	.000	− .001	.000	.000	.000	− .001	23.46368	354 4 51.5
$N_3'N_6'^2$	+ .172	− .002	− .428	+ .007	+ .001	+ .170	− .420	25.54881	192 17 36.9
$N_3'N_7'^2$	+ .364	− .004	− .906	+ .014	+ .003	+ .360	− .889	63.06296	31 57 6.3
$N_4'N_5'^2$	+ 0.005	.000	− 0.012	.000	.000	+ 0.005	− 0.012	6.06680	290 4 23.5
$N_4'N_6'^2$	+ 1.508	− .018	− 3.748	+ .062	+ .012	+ 1.490	− 3.674	8.15194	128 17 8.9
$N_4'N_7'^2$	+ 3.189	− .038	− 7.929	+ 0.128	+ .026	+ 3.151	− 7.775	45.66609	327 56 38.3
$N_5'N_6'^2$	+ 37.674	− .461	− 93.653	+ 1.552	+ .310	+ 37.213	− 91.791	10.19548	164 56 49.3
$N_5'N_7'^2$	+ 79.694	− 0.950	− 198.099	+ 3.198	+ 0.639	+ 78.744	− 194.262	47.70963	4 36 18.7
$N_6'N_7'^2$	+1132.374	−17.061	−3560.683	+57.439	+11.480	+1415.310	−3491.764	48.75219	283 42 41.4
$N_4'^2N_6'$	+ 0.003	0.000	− 0.008	0.000	0.000	+ 0.003	− 0.008	5.06583	172 31 5.8
$N_4'^2N_7'$	− 0.005	.000	+ 0.012	.000	.000	− 0.005	+ 0.012	23.82291	92 20 50.5
$N_5'^2N_6'$	+ 2.096	− .026	− 5.211	+ .087	+ .017	+ 2.070	− 5.107	9.15291	245 50 26.6
$N_5'^2N_7'$	− 3.048	+ 0.037	+ 7.577	− 0.121	− 0.025	− 3.011	+ 7.431	27.90999	165 40 11.3
$N_6'^2N_7'$	− 984.657	+11.885	+2147.720	−40.007	− 7.996	− 972.772	+2399.717	29.99512	3 52 56.7
$N'N_4'N_6'$	− 0.001	+ 0.000	+ 0.002	0.000	0.000	− 0.001	+ 0.002	9.80057	186 34 19.4
$N'N_4'N_7'$	+ .001	.000	− .002	.000	.000	+ .001	− .002	28.55765	106 24 4.1
$N'N_5'N_6'$	− .016	.000	+ .041	− .001	.000	− .016	+ .040	11.84411	223 13 59.8
$N'N_5'N_7'$	+ .024	.000	− 0.059	+ .001	.000	+ .024	0.058	30.60119	143 3 44.5
$N'N_6'N_7'$	+ .428	− .005	− 1.065	+ .017	+ .004	+ .423	− 1.044	31.64375	62 10 7.2
$N_1'N_4'N_6'$	+ .001	.000	− 0.002	.000	.000	+ .001	− 0.002	11.80021	112 25 6.2
$N_1'N_4'N_7'$	− .001	.000	+ .002	.000	.000	− .001	+ .002	30.55728	32 14 50.9
$N_1'N_5'N_6'$	+ 0.024	0.000	− 0.061	+ 0.001	0.000	+ 0.024	− 0.060	13.84375	149 4 46.6

	L	C	L'	C'	P	Σ	Σ'	S	D
	″	″	″	″	″	″	″	″	° ′ ″
$N_1'N_5'N_7'$	— 0.036	0.000	+ 0.089	— 0.001	0.000	— 0.036	+ 0.088	32.60082	68 54 31.3
$N_1'N_6'N_7'$	— .641	+ .008	+ 1.592	— .026	— .005	— .633	+ 1.561	33.64339	348 0 54.0
$N_2'N_4'N_6'$	— .001	.000	+ 0.001	.000	.000	— .001	+ 0.001	21.79441	72 41 37.2
$N_2'N_4'N_7'$	+ .001	.000	— .001	.000	.000	+ .001	— .001	40.55152	352 31 21.9
$N_2'N_5'N_6'$	— .015	.000	+ .038	— .001	.000	— .015	+ .037	23.83798	109 21 17.6
$N_2'N_5'N_7'$	+ .022	.000	— 0.056	+ .001	.000	+ .022	— .055	42.59506	29 14 2.3
$N_2'N_6'N_7'$	+ .404	— .005	— 1.005	+ .016	+ .004	+ .399	— .985	43.63762	308 20 25.0
$N_3'N_4'N_6'$	+ .001	.000	— 0.001	.000	.000	+ .001	— .001	22.46270	236 31 33.8
$N_3'N_4'N_7'$	— .001	.000	+ .001	.000	.000	— .001	+ .001	41.21978	156 21 18.5
$N_3'N_5'N_6'$	+ .019	.000	— .048	+ .001	.000	+ .019	— .047	24.50624	273 11 14.2
$N_3'N_5'N_7'$	— .028	.000	+ 0.069	— .001	.000	— .028	+ 0.068	43.26332	193 0 58.9
$N_3'N_6'N_7'$	— .501	+ .006	+ 1.245	— .020	— .004	— .495	+ 1.221	41.30588	112 7 31.6
$N_4'N_5'N_6'$	+ .168	— .002	— 0.417	+ .007	+ .001	+ .166	— 0.409	7.10937	209 10 45.2
$N_4'N_5'N_7'$	— 0.244	+ .003	+ 0 607	— .007	— .002	— 0.241	+ 0.598	25.86645	129 0 30.9
$N_4'N_6'N_7'$	— 4.385	+ 0.053	+ 10.901	— 0.178	— .036	— 4.332	+ 10.687	26.90901	45 6 53.6
$N_5'N_6'N_7'$	— 109.540	+ 1.323	+ 272.301	— 4.455	— 0.890	— 108.217	+ 266.956	28.75255	84 46 34.0

V. INEQUALITIES ARISING FROM $H_5 e\eta^2 \cos(V-\varpi-2\tau')$.

	L	C	P	L'	C'	Σ	Σ'	S	D
	″	″	″	″	″	″	″	″	° ′ ″
$N_5 W_6^2$	—0.002	0.000	0.000	+ 0.005	0.000	—0.002	+ 0.005	8.54915	200 55 4.5
$N_6 W_6^2$	— .040	+ .001	.000	+ .099	— .004	— .039	+ .095	9.59207	120 1 27.2
$N_7 W_6^2$	— .015	.000	.000	+ .036	— .002	— .015	+ .034	28.34915	39 51 11.9
$N W_7^2$	+ .001	.000	.000	— .001	.000	+ .001	— .001	57.34346	193 36 6.3
$N_1 W_7^2$	— .002	.000	.000	+ .005	.000	— .002	+ .005	59.34309	119 26 53.1
$N_4 W_7^2$	— .012	.000	.000	+ .031	— .001	— .012	+ .030	52.60871	179 32 52.5
$N_5 W_7^2$	—0.388	+ .011	— .002	+ 0.964	— .039	—0.379	+ 0.925	54.65225	216 12 32.9
$N_6 W_7^2$	—8.088	+ .236	— .035	+20.107	— .821	—7.889	+19.286	55.69482	135 18 55.6
$N_7 W_7^2$	—2.993	+ .086	— .012	+ 7.439	— .300	—2.919	+ 7.139	74.45189	54 8 40.3
$N_6 W W_7$	—0.004	.000	.000	+ 0.008	.000	—0.004	+ 0.008	34.86934	63 49 21 2
$N_7 W W_7$	— .001	.000	.000	+ .003	.000	— .001	+ .003	53.62642	343 39 5.9
$N_6 W_1 W_7$	+ .004	.000	.000	— .010	.000	+ .004	— .010	36.35068	307 30 11.4
$N_7 W_1 W_7$	+ .001	.000	.000	— .002	.000	+ .001	— .002	55.10776	227 23 26.2
$N_6 W_2 W_7$	— .012	.000	.000	+ .029	— .001	— .012	+ .028	12.64008	144 48 7.1
$N_7 W_2 W_7$	— .004	.000	.000	+ .011	.000	— .004	+ .011	31.39715	64 37 51.8
$N_6 W_3 W_6$	.000	.000	.000	+ .001	.000	.000	+ .001	25.82790	359 30 54.5
$N_6 W_3 W_7$	— .003	.000	.000	+ .008	.000	— .003	+ .008	48.87928	187 9 38.7
$N_7 W_3 W_7$	— .001	.000	.000	+ .003	.000	— .001	+ .003	67.63635	106 59 23.4
$N_5 W_5 W_6$	.000	.000	.000	+ .001	.000	.000	+ .001	6.33135	313 42 27.2
$N_6 W_5 W_6$	— .005	.000	.000	+ .015	— .001	— .005	+ .014	7.37391	232 48 49.9
$N_7 W_5 W_6$	— .002	.000	.000	+ .006	.000	— .002	+ .006	26.13099	152 38 34.6
$N_5 W_5 W_7$	— .004	.000	.000	— .008	.000	— .004	— .008	29.38272	141 21 11.4
$N_6 W_5 W_7$	— .086	+ .002	.000	+ .215	— .009	— .084	+ .206	30.42538	60 27 34.1
$N_7 W_5 W_7$	— .032	+ .001	.000	+ .080	— .003	— .031	+ .077	49.18235	340 16 18.8
$N_4 W_6 W_7$	— .002	.000	.000	+ .004	.000	— .002	+ .004	29.55731	351 54 8.3
$N_5 W_6 W_7$	—0.054	+ .001	.000	+ .135	— .006	—0.053	+ .129	31.60088	28 33 48.7
$N_6 W_6 W_7$	—1.134	+ .032	— .006	+ 2.820	— .117	—1.108	+ 2.703	32.64345	307 30 11.4
$N_7 W_6 W_7$	—0.420	+0.012	—0.002	+ 1.042	—0.043	—0.410	+ 0.999	51.40052	226 19 56.1

VI. INEQUALITIES ARISING FROM $H_6 e'\eta^2 \cos(V-\varpi'-2\tau')$.

	L	C	L'	C'	P'	Σ	Σ'	S	D
	″	″	″	″	″	″	″	″	° ′ ″
$N_5' W_6^2$	+ 0.003	0.000	— 0.008	0.000	0.000	+ 0.003	— 0.008	8.54951	200 55 4.5
$N_6' W_6^2$	+ .060	— .001	— .150	+ .005	.000	+ .059	— .145	9.59207	120 1 27.2
$N_7' W_6^2$	— .088	+ .002	+ .218	— .006	.000	— .086	+ .212	28.34915	39 51 11.9
$N' W_7^2$	— .003	.000	+ .007	.000	.000	— .003	+ .007	57.31345	193 36 6.1
$N_1' W_7^2$	+ .004	.000	— .010	.000	.000	+ .004	— .010	59.34309	119 26 52.9
$N_2' W_7^2$	— 0.003	0.000	+ 0.006	0.000	0.000	— 0.003	+ 0.006	69.33733	79 46 23.9

	L	C	L′	C′	P′	Σ	Σ′	s	D
	″	″	″	″	″	″	″	″	° ′ ″
$N_3'W_7^2$	+ 0.003	0.000	— 0.008	0.000	0.000	+ 0.003	— 0.008	70.00559	243 33 20.5
$N_4'W_7^2$	+ .027	— .001	— 0.068	+ .002	.000	+ .026	— 0.066	52.60871	179 32 52.5
$N_5'W_7^2$	+ 0.682	— .017	— 1.691	+ .049	+ .002	+ 0.665	— 1.643	54.65225	216 12 32.9
$N_6'W_7^2$	+12.248	— .304	—30.446	+0.880	+ .033	+11.914	—29.533	55.69482	135 18 55.6
$N_7'W_7^2$	—17.825	+ .436	+44.311	—1.263	— .047	—17.389	+43.001	74.45189	51 8 40.3
$N_6'WW_7$	+ 0.005	.000	— 0.012	0.000	.000	+ 0.005	— 0.012	34.86934	63 49 21.2
$N_7'WW_7$	— .008	.000	+ .018	.000	.000	— .008	+ .018	53.62642	313 39 5.9
$N_6'W_1W_7$	— .006	.000	+ .016	.000	.000	— .006	+ .016	36.35068	307 33 41.5
$N_7'W_1W_7$	+ .009	.000	— .023	+ .001	.000	+ .009	— .023	55.10776	227 23 26.2
$N_6'W_2W_7$	+ .018	.000	— .041	+ .001	.000	+ .018	— .043	12.64008	144 48 7.1
$N_7'W_2W_7$	— .026	+ .001	+ .065	— .002	.000	— .025	+ .063	31.39715	64 37 51.8
$N_6W_3W_6$	.000	.000	— .001	.000	.000	.000	— .001	25.82790	359 30 54.5
$N_7W_3W_6$	.000	.000	+ .001	.000	.000	.000	+ .001	44.58498	279 20 39.2
$N_5W_4W_7$	.000	.000	— .001	.000	.000	0.00	— .001	47.83671	268 3 16.0
$N_6'W_4W_7$	+ .005	.000	— .012	.000	.000	+ .005	— .012	48.87928	187 9 38.7
$N_7'W_4W_7$	— .007	.000	+ .018	.000	.000	— .007	+ .018	67.63635	106 59 23.4
$N_5'W_5W_6$	+ .001	.000	— .001	.000	.000	+ .001	— .001	6.33135	313 42 27.2
$N_6'W_5W_6$	+ .008	.000	— .023	+ .001	.000	+ .008	— .022	7.37391	232 48 49.9
$N_7'W_5W_6$	— .014	.000	+ .033	— .001	.000	— .014	+ .032	26.13099	152 38 34.6
$N_5'W_5W_7$	+ .007	.000	— .014	.000	.000	+ .007	— .014	29.38272	141 21 11.4
$N_6'W_5W_7$	+ .131	— .003	— .326	+ .010	.000	+ .128	— .316	30.42538	60 27 34.1
$N_7'W_5W_7$	— .190	+ .005	+ .473	— .014	— .001	— .185	+ .458	49.18235	340 16 18.8
$N_4'W_6W_7$	+ .004	.000	— .010	.000	.000	+ .004	— .010	29.55734	351 54 8.3
$N_5'W_6W_7$	+ 0.096	— .003	— 0.238	+ .007	.000	+ 0.093	— 0.231	31.60088	28 33 48.7
$N_6'W_6W_7$	+ 1.717	— .043	— 4.270	+ .125	+ .005	+ 1.674	— 4.140	32.64315	307 30 11.4
$N_7'W_6W_7$	— 2.198	+0.062	+ 6.210	—0.180	—0.007	— 2.436	+ 6.023	51.40052	226 19 56.1

VII. INEQUALITIES ARISING FROM FORMULA (VII).

	Q	Q′	s	D
	″	″	″	° ′ ″
$N_6M_5W_7$	—0.001	+0.003	—22.93326	355 37 30.9
$N_7M_5W_7$	.000	+ .001	— 4.17618	275 24 18.6
$N_6M_6W_7$	— .002	+ .004	—25.15142	108 21 56.6
$N_7M_6W_7$	— .001	+ .002	— 6.39434	27 11 41.3
$N_6M_7W_6$	.000	+ .001	—25.15142	108 21 56.6
$N_5M_7W_7$	.000	+ .001	—49.24536	1 36 49.7
$N_6M_7W_7$	— .005	+ .012	—48.20280	280 43 12.4
$N_7M_7W_7$	—0.002	+0.001	—29.44572	200 32 57.1

VIII. INEQUALITIES ARISING FROM FORMULA (VIII).

	Q	Q′	s	D
	″	″	″	° ′ ″
$N_6'M_5W_7$	+0.002	—0.004	—22.93326	355 37 30.9
$N_7'M_5W_7$	— .002	+ .006	— 4.17618	275 24 18.6
$N_6'M_6W_7$	.000	— .006	—25.15142	108 21 56.6
$N_7'M_6W_7$	— .004	+ .009	— 6.39434	27 11 41.3
$N_6'M_7W_6$	+ .003	— .001	—25.15142	108 21 56.6
$N_7'M_7W_6$	— .001	+ .002	— 6.39434	27 11 41.3
$N_5'M_7W_7$	.000	— .001	—49.24536	1 36 49.7
$N_6'M_7W_7$	+ .007	— .017	—48.20280	280 43 12.4
$N_7'M_7W_7$	—0.010	+0.025	—29.44572	200 32 57.1

IX. SUMMATION OF PRECEDING INEQUALITIES.

	Σ	Σ′	s	D		Σ	Σ′	s	D
	″	″	″	° ′ ″		″	″	″	° ′ ″
N_7^3	—1175.337	+2900.013	+67.50927	203 32 26.1	$N_5^2N_7$	— 0.385	+ 0.960	+27.90999	165 40 11.3
$N_6N_7^2$	+ 464.751	—1146.607	18.75219	283 42 41.4	$N_2N_7^2$	— 0.379	+ 0.937	62.39470	228 10 9.7
$N_6^2N_7$	— 53.888	+ 132.952	29.99512	3 52 56.7	$N_5W_7^2$	+ 0.286	— 0.718	54.65225	216 12 32.9
$N_5N_7^2$	+ 37.882	— 93.151	17.70963	4 36 18.7	$N_1N_7^2$	+ 0.274	— 0.675	52.40046	267 50 38.7
$N_7W_7^2$	— 20.308	+ 50.140	74.45189	51 8 40.3	$N_7W_5W_7$	— 0.216	+ 0.535	49.18235	340 16 18.8
$N_5N_6N_7$	— 9.251	+ 22.839	28.75225	84 16 34.0	$N_4N_7^2$	— 0.147	+ 0.364	50.40083	341 59 51.9
$N_6W_7^2$	+ 4.055	— 10.247	55.69482	135 18 55.6	$N_3N_6N_7$	— 0.128	+ 0.315	44.30588	112 7 31.6
$N_7W_6W_7$	— 2.846	+ 7.022	51.40052	226 19 56.1	$N_7W_6^2$	— 0.101	+ 0.246	28.34915	39 51 11.9
$N_4N_7^2$	+ 2.074	— 5.115	15.66609	327 56 38.3	$N_2N_6N_7$	+ 0.099	— 0.244	43.63762	308 20 25.0
N_6^3	+ 1.275	— 3.142	11.23804	84 3 12.0	$N_1N_6N_7$	— 0.068	+ 0.166	33.64339	318 0 54.0
$N_6W_6W_7$	+ 0.566	— 1.137	32.64345	307 30 11.4	$N_6W_5W_7$	+ 0.044	— 0.110	30.42538	60 27 34.1
$N_4N_6N_7$	— 0.523	+ 1.283	26.90901	48 6 53.6	$N_4N_5N_7$	— 0.044	+ 0.112	25.86645	129 0 30.9
$N_3N_7^2$	+ 0.189	— 1.208	63.06295	31 57 6.3	$N_5W_6W_7$	+ 0.040	— 0.102	31.60088	28 33 48.7
$N_5N_6^2$	+ 0.119	— 1.027	+10.19548	164 56 49.3	$N_5^2N_6$	+ 0.036	— 0.088	+ 9.15291	245 50 26.6

	Σ	Σ′	S	D		Σ	Σ′	S	D
	″	″	″	° ′ ″		″	″	″	° ′ ″
NN_6N_7	+0.035	−0.089	+31.64375	62 10 7.2	NN_5N_6	+0.002	+0.001	+11.84411	223 13 59.8
$N_7W_2W_7$	−0.029	+0.074	31.39715	64 37 51.8	$N_1N_5N_6$	+0.002	−0.002	13.84375	149 4 16.6
$N_4N_6^2$	+0.023	−0.068	8.15194	128 17 8.9	$N_3N_5N_6$	+0.002	−0.004	24.50624	273 11 14.2
$N_6W_6^2$	+0.020	−0.050	9.59207	120 1 27.2	$N_1W_7^2$	+0.002	−0.005	59.34309	119 26 53.1
$N_7W_5W_6$	−0.016	+0.038	26.13099	152 38 34.6	$N_6W_3W_7$	+0.002	−0.004	48.87928	187 9 38.7
$N_4W_7^2$	+0.014	−0.036	+52.60871	179 32 52.5	$N_4W_6W_7$	+0.002	−0.006	29.55734	351 54 8.3
$N_7M_7W_7$	−0.012	+0.029	−29.44572	200 32 57.1	$N_1N_6^2$	+0.002	−0.011	+11.88631	69 11 9.3
$N_7W_1W_7$	+0.010	−0.025	+55.10776	227 23 26.2	$N_7M_5W_7$	−0.002	+0.007	− 1.17618	275 21 18.6
$N_3N_5N_7$	−0.010	+0.026	43.26332	193 0 58.9	NN_6^2	−0.002	+0.008	+12.88668	142 20 22.5
N_7WW_7	−0.009	+0.021	53.62642	343 39 5.9	NW_7^2	−0.002	+0.006	57.34346	193 36 6.3
$N_7W_3W_7$	−0.008	+0.021	67.63635	106 59 23.4	$N_6W_1W_7$	−0.002	+0.006	36.35069	307 33 41.5
$N_3N_6^2$	+0.007	−0.019	25.54881	192 17 36.9	$N_1N_4N_6$	−0.002	0.000	11.80021	112 25 6.2
$N_2N_5N_7$	+0.007	−0.021	42.59506	29 14 2.3	$N_3N_5^2$	+0.001	+0.001	23.46368	351 4 51.5
$N_6W_2W_7$	+0.006	−0.015	12.64008	144 48 7.1	$N_2N_5^2$	+0.001	0.000	22.79512	190 17 54.9
$N_1N_5N_7$	−0.006	+0.015	+32.60082	68 54 31.3	$N_4^2N_6$	+0.001	0.000	5.06583	172 31 5.8
$N_7M_6W_7$	−0.005	+0.013	− 6.39434	27 11 4.3	$N_1N_4N_7$	+0.001	0.000	30.55728	32 11 50.9
$N_2N_6^2$	−0.005	+0.015	+24.88055	28 30 40.3	$N_2N_4N_7$	+0.001	0.000	40.55152	352 34 21.9
NN_5N_7	−0.005	+0.013	30.60119	143 3 44.5	$N_5W_6^2$	+0.001	−0.003	8.51951	200 55 4.5
$N_4N_5N_6$	−0.005	+0.010	7.10937	209 10 45.2	$N_3N_4N_6$	+0.001	−0.001	22.16270	236 31 33.8
$N_6W_5W_6$	+0.003	−0.008	7.37391	232 48 19.9	N_6WW_7	+0.001	−0.004	34.86934	63 49 21.2
$N_3W_7^2$	+0.003	−0.008	70.00559	243 33 20.5	$N_5W_5W_6$	+0.001	0.000	6.33135	313 42 27.2
$N_5W_5W_7$	+0.003	−0.006	29.38272	141 21 11.4	$N_1N_5^2$	+0.001	−0.001	12.80118	229 58 23.9
$N_2W_7^2$	−0.003	+0.006	+69.33733	79 46 23.9	$N_2N_5N_6$	−0.001	+0.001	23.83798	109 21 17.6
$N_6M_7W_7$	+0.002	−0.005	−48.20280	280 43 12.4	$N_4^2N_7$	−0.001	+0.003	23.82291	92 20 50.5
$N_6M_7W_6$	+0.002	−0.003	−25.15142	108 21 56.6	$N_2N_4N_6$	−0.001	−0.001	21.79414	72 44 37.2
N_5^3	+0.002	−0.002	+ 8.11035	326 44 3.9	$N_3N_4N_7$	−0.001	+0.001	+11.21978	156 21 18.5

X. Δ and Δ′. $\delta l = 1160''.36 \sin(V'+270°\ 12'\ 19''.9)$. $\delta l' = -2862''.14 \sin(V'+270°\ 11'54''.8)$. $V' = 1399''.77167\,t$
Epoch 1850.

t	Δ	Δ′	t	Δ	Δ′	t	Δ	Δ′
	″	″		″	″		″	″
−2500	−102.68	+253.25	−50	−1.00	+2.46	+ 60	− 0.71	+ 1.75
−2000	− 80.45	+198.41	−40	−0.69	+1.70	+ 70	− 1.03	+ 2.55
−1500	+ 51.45	−126.06	−30	−0.43	+1.08	+ 80	− 1.40	+ 3.46
−1000	− 25.80	+ 63.43	−20	−0.23	+0.57	+ 90	− 1.82	+ 4.48
− 500	+ 7.80	− 18.99	−10	−0.07	+0.17	+ 100	− 2.27	+ 5.62
− 100	− 3.18	+ 7.86	+10	+0.01	−0.02	+ 500	+ 3.88	− 9.58
− 90	− 2.68	+ 6.60	+20	0.00	0.00	+1000	−19.04	+ 46.98
− 80	− 2.20	+ 5.42	+30	−0.08	+0.22	+1500	+41.62	−102.68
− 70	− 1.76	+ 4.33	+40	−0.24	+0.59	+2000	+73.05	−180.35
− 60	− 1.35	+ 3.35	+50	−0.44	+1.10	+2500	+98.21	−242.31

Leander McCormick Observatory, University of Virginia, 1895 *May* 1.

THE LATITUDE-VARIATION TIDE,

BY S. C. CHANDLER.

Shortly after the announcement of the 427-day period of revolution of the earth's axes of figure and rotation, the ingenious suggestion was made by Prof. NEWCOMB that, if such a phenomenon existed, it should cause a synchronous oscillation in the mean sea-level, which might be detected by a careful study of the tidal observations of the U. S. Coast Survey. Acting upon this suggestion the Superintendent of the Survey authorized Dr. A. S. CHRISTIE, the head of its Tidal Division, to make such an examination. Dr. CHRISTIE accordingly chose the observations made at two mareograph stations near San Francisco, Cal., and in February 1892 he communicated his results in an official report. He found, from a 35-years series extending from 1856 to 1891, a tide with a period of 437.4 days, and a semi-amplitude of 17.3 mm. These results were communicated to the National Academy at Washington, April 1892, in elaborate detail, and excited the liveliest interest among the astronomical members there present. Immediately thereafter Dr. Christie undertook the reduction of the Coast-Survey tidal observations in Penobscot Bay, Maine, extending from 1870 to 1888, and found, similarly, a tide with a period of 424.9 days, and a semi-amplitude of 12.5 mm. These results, together with those which he had previously announced with regard to the Pacific coast tide, he communicated to the Philosophical Society of Washington, May 21 1892. The epochs of maxima and minima at both stations were entirely harmonious, and the combination of the two series gave a mean period of 431 ± 4 days, and a mean semi-amplitude of 15 mm, or 0.59 inches.

These results of Dr. Christie's, it will be seen, are in quite satisfactory accord with those published two years later by Prof. van de Sande Bakhuyzen, based on the tidal observations at Helder, near Amsterdam, 1855–1892. The agreement is all the more satisfactory because Prof. Bakhuyzen appears to have been unaware that his researches had been so long anticipated by those of Dr. Christie.

The phase-epochs from these tidal investigations show a most remarkable accord with those derived from astronomical observation upon latitudes. If the variation of sea-level is caused by the divergence of the earth's axes of rotation and figure, low tide at any station must occur when the pole of rotation lies between the pole of figure and the station, *i.e.*, at the time of maximum latitude at that station. Now the Julian date of the low tide at Greenwich, according to these investigations, would be,

San Francisco (Christie).	2405137
Helder (Bakhuyzen).	2405185
Mean,	2405161

But, by equation (52), *Astron. Journal*, no. 322, the Greenwich epoch of maximum latitude, for the 428-day term, is 2405164. Thus the difference between the results is only three days in this case.

Similarly we have the date of low tide at Greenwich from the observations at

Penobscot Bay (Christie),	2407302
While formula (52) gives	2407310

where the difference is only eight days.

The range of the tide, as determined by the observations on the Pacific coast, is one and a third inches; that on the west Atlantic shore is one inch; and that on the east shore is two-thirds of an inch. Notwithstanding the natural distrust attaching to investigations so delicate, upon a phenomenon almost evanescent in its character, the harmony between the results of tidal and astronomical observation, as exemplified above in the dates of the principal phases, can hardly be regarded as fortuitous.

OBSERVATION 1895 JANUARY 27 OF THE COMET *e* 1894 (*SWIFT*),

MADE WITH THE 36-INCH REFRACTOR OF THE LICK OBSERVATORY,

By E. E. BARNARD.

I have measured the position of the 13^M comparison-star used with Swift's comet 1895 Jan. 27, with reference to the star Weisse-Bessel I, 245, which is Schjellerup 428. The following position of the comet results.

1895 Mt. Hamilton M.T.	*	No. Comp.	☄ − * $\Delta\alpha$	☄ − * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
Jan. 27 $7^h\ 16^m\ 12^s$	3	5, 6	$-0^m\ 15^s.35$	$+1'\ 9''.7$	$1^h\ 17^m\ 42^s.07$	$+8°\ 26'\ 10''.1$	9.445	0.648

Mean Place for 1895.0 of Comparison-Star.

*	α	Red. to app. place	δ	Red. to app. place
3	$1^h\ 17^m\ 57^s.41$	$-0^s.02$	$+8°\ 21'\ 57''.0$	$+3''.4$

In *A.J.* no. 338, p. 10, in giving the rough approximate position of the 13^M star, I see that I have added the $\Delta\alpha$, instead of subtracting it. See the previous page, where the $\Delta\alpha$ is shown to be minus. The $\Delta\alpha$ and $\Delta\delta$ for the 13^M star and the star DM. 8°220, as given on p. 9, are correct.

Mt. Hamilton, 1895 *July* 26.

NEW ASTEROIDS.

In *Astron. Nachr.* 3302, Mr. Berberich gives an ephemeris computed by him for an asteroid *BY*, 12^M, not previously announced, but discovered by Charlois 1895 June 20.

Prof. Kreutz communicates the discovery of two others, also by Mr. Charlois, upon a photograph taken July 23: $10^h\ 51^m.0$ Nice M.T.

BZ 11^M $\alpha = 20^h\ 9^m\ 16^s$, $\delta = -5°\ 36'$. Daily motion, -1^m in α.
CA $11\frac{1}{2}^M$ $\alpha = 20^h\ 23^m\ 18^s$, $\delta = -8°\ 52'$. Daily motion, -1^m in α, and 1′ southward.

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Observation 1895 January 27 of the Comet *e* 1894 (Swift), by Prof. E. E. Barnard.
New Asteroids.

Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed August 6.*

THE

ASTRONOMICAL JOURNAL.

No. 352.

VOL. XV. BOSTON, 1895 AUGUST 29. NO. 16

RESEARCHES ON THE ORBIT OF γ *VIRGINIS* = Σ1670,

By T. J. J. SEE.

This celebrated double star was accidentally discovered by Bradley and Pound March 15, 1718. The only double star previously recognized which has proved to be binary is *α Centauri.* It was resolved into its components in December, 1689, by Father Richaud, at Pondicherry, India. On putting one eye to the telescope, and looking at the heavens with the other, Bradley found the two components of *γ Virginis* to be approximately in line with the naked-eye stars *α* and *δ Virginis:* this allineation gives a position-angle of 330°.8 at the epoch 1718.20. Such an observation has of course some historical interest, but is worthy of little consideration in the discussion of a modern double-star orbit. Neither can any confidence be placed in the position for 1720, which was calculated from a lunar occultation observed by Cassini while searching for evidence of an atmosphere surrounding the Moon.

The observation which results from the Catalogue of Tobias Mayer would be entitled to more weight were it not for the uncertainty of double-star positions deduced from differences of right-ascension and declination.

Therefore, in the present discussion of the orbit I have relied principally upon observations since the time of William Struve, but have not entirely ignored the measures of Sir William Herschel, which appear to be as good as could be expected from the means at his disposal. After an examination of all the observations, it appeared advisable to base the orbit mainly upon the work of the great standard observers. This sifting of the observational material is rendered the more necessary by the great number and miscellaneous character of the observers who have occupied themselves with an easy and celebrated star like *γ Virginis.* It is probable that more orbits have been computed for this star than for any other binary in the heavens, but as all of these are defective, according to trustworthy recent observations, a new determination of the elements based upon the best measures now available, would seem to be desirable. In dealing with an orbit which has long occupied the attention of eminent men, including Sir John Herschel and the illustrious Adams, we could hardly hope for material improvement over the results already obtained, were not the investigation rendered more complete by recent observations, and by the use of the observed distances, which have generally been rejected, but which here acquire a high importance owing to the slow angular motion. The nature of the motion of *γ Virginis* is such that some of the elements, especially the periastron passage and the eccentricity, are determined with great precision; but the period has been underestimated by nearly all recent investigators, and will still remain slightly uncertain, perhaps to the extent of one year. The following table of elements has been made up chiefly from original sources, but in a few cases I have relied upon Mr. Gore's useful "Catalogue of Binary Stars for which Orbits have been Computed."

P	T	e	a	Ω	i	λ	Authority		Source
			″	°	°	°			
513.28	1834.01	0.8872	11.830	87.83	68.0	290.0	Herschel,	1830 (?)	Mem. R.A.S., vol. V
628.90	1834.63	0.8335	12.09	97.4	67.03	282.35	Herschel,	1833	Mem. R.A.S., vol. VI
145.453	1836.313	0.8681	3.402	60.63	24.65	78.37	Mädler,	1841	Dorpat obs., 1841
157.562	1836.103	0.8680	3.638	58.38	35.6	266.0	Mädler,	1841	A.N. 363
143.44	1836.29	0.8590	–	70.6	23.1	319.38	Henderson,	1843	"Spec. Hartw., p. 345
141.297	1836 228	0.8566	–	78.47	25.23	319.77	Hind,	1845	Mem. R.A.S., vol. XVI, p. 461
133.5	1836.30	0.8525	3.499	69.67	24.6	249.3	Jacob,	1846	
169.445	1836.279	0.8806	–	62.15	25.42	79.07	Mädler,	1847	Die Fixstern-Systeme
182.12	1836.43	0.8795	–	5.55	23.6	313.75	Herschel,	1847	'Results.' p. 297
183.137	1836.385	0.8860	4.336	28.7	30.65	290.5	Herschel,	1850	Mem. R.A.S., vol. XVIII, p. 67

P	T	e	a	☊	i	λ	Authority	Source
			″	°	°	°		
171.54	1836.40	0.8804	–	20.57	27.38	300.2	Hind, 1851	M.N., vol. XI, p. 136
171.137	1836.31	0.8796	–	34.75	25.45	284.9	Adams, 1851	
184.53	1836.40	0.8794	–	19.12	27.6	295.2	Fletcher, 1853	M.N., vol. XIII, p. 258
148.2	1836.2	0.8725	3.617	41.67	31.95	269.3	Smyth, 1860	'Cycle,' p. 356
177.7	1836.50	0.8878	4.226	35.62	37.33	281.7	Smyth, 1860	'Cycle' cont., p. 45
185.0	1836.68	0.896	3.97	35.6	35.1	283.7	Thiele, 1866	A.N., vol. XVIII
175.0	1836.45	0.8715	3.385	–	0.0	long. per. = 320.0	Flammarion, 1874	'Catalogue,' p. 72
180.54	1836.47	0.8978	4.09	45.82	37.0	93.98	Doberck, 1881	Copernicus, vol. I, p. 143
179.65	1836.45	0.8904	3.94	46.0	33.95	93.92	Doberek, 1881	Copernicus, vol. I, p. 143
192.07	1836.51	0.895	4.144	54.9	34.12	271.23	See, 1893	Astron. and Astro.-Phys., Dec.'93

From an investigation of the long list of observations, including my own very careful measures recently secured with the 26-inch refractor of the Leander McCormick Observatory of the University of Virginia, I find the following elements of γ *Virginis*:

P = 194.0 years
T = 1836.53
e = 0.8974
a = 3″.989
☊ = 50°.4
i = 31.0
λ = 270°.0
n = −1°.8557

Apparent orbit:

Length of major axis	= 6″.824
Length of minor axis	= 3″.530
Angle of major axis	= 140°.4
Angle of periastron	= 140.4
Distance of star from center	= 3″.062

The accompanying table of computed and observed places shows that these are perhaps the most exact elements yet determined for any star. For although all the measures have not been used in forming the mean observations on which the orbit is based, yet those measures which have been employed have been so combined as fairly to represent the best material for each year. Accordingly, the residuals are uniformly small, except just before periastron passage, when the object was extremely difficult; and, as no variation of the elements will materially improve the representation of the observations in this part of the orbit without a corresponding damage elsewhere, we infer that the differences are due mainly to systematic errors in Struve's measures.

Comparison of Computed with Observed Places.

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
	°		″	″	°	″		
1718.20	330.8	326.2	–	6.27	+ 4.6	–	2	Bradley and Pound
1720.31	319.0	325.0	7.49	6.34	− 6.0	+1.15	1	Cassini
1756.20	324.4	318.7	6.50	6.46	+ 5.7	+0.04	–	Tobias Mayer
1781.89	310.7	308.1	5.70	5.67	+ 2.6	+0.03	1	Herschel
1803.37	300.2	299.6	–	4.60	+ 0.6	–	8 obs.	Herschel
1819.40	–	286.9	3.56	3.16	–	+0.40	1+	Struve
1820.28	284.9	284.9	2.76	2.97	0.0	−0.21	5	Struve
1822.25	283.4	283.4	3.79	2.85	0.0	−0.06	2	Herschel and South
1823.32	281.6	281.8	2.95	2.70	− 0.2	+0.25	1, 3	Struve
1825.32	277.9	278.2	2.37	2.43	− 0.3	−0.06	6	Struve
1828.38	271.5	271.4	2.07	2.01	+ 0.1	+0.06	1	Struve
1829.30	268.0	268.8	1.78	1.86	− 0.8	−0.08	7	H., 2 : Σ., 5
1830.59	262.2	264.1	1.59	1.63	− 1.9	−0.04	7	Bessel
1831.36	260.9	260.8	1.49	1.50	+ 0.1	−0.01	5	Struve
1832.52	253.5	253.8	1.26	1.26	− 0.3	0.00	4	Struve
1833.36	240.1	247.2	1.14	1.09	− 7.1	+0.05	8, 2	Dawes
1833.37	245.5	247.1	1.05	1.08	− 1.6	−0.03	7	Struve
1834.38	231.6	235.0	0.91	0.84	− 3.4	+0.07	5	Struve
1834.84	213.6	226.5	–	0.72	−12.9	–	1	Struve
1835.38	195.5	212.2	0.51	0.58	−16.7	−0.07	9	Struve
1835.39	195.2	212.0	0.57	0.57	−16.8	0.00	1	Senff
1835.42	197.1	211.3	–	0.56	−14.2	–	1	O. Struve
1836.41	151.6	150.2	0.26	0.36	+ 1.4	−0.10	3	Struve

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
	°		"	"	°	"		
1836.41	158.7	150.2	–	0.36	+ 8.5	–	2	O. Struve
1836.41	153.8	150.2	–	0.36	+ 3.6	–	1	Sabler
1837.41	77.9	78.2	0.58	0.52	– 0.3	+0.06	6	O. Struve
1837.41	78.5	78.2	0.67	0.52	+ 0.3	+0.15	1	Encke
1838.08	57.5	58.0	0.67	0.70	– 0.5	–0.03	1	Herschel
1838.40	51.9	50.8	0.86	0.78	+ 1.1	+0.08	–	Struve
1838.43	51.1	50.0	0.80	0.79	+ 1.1	+0.01	–	O. Struve
1838.43	49 2	50.0	0.83	0.79	– 0.8	+0.04	3 ±	Galle and Mädler
1839.33	35.5	37.3	1.26	1.01	– 1.8	+0.25	5, 1	Galle, 5–0; Dawes, 0–1.
1840.36	26.3	28.1	1.28	1.23	– 1.8	+0.05	16, 12 ±	Kaiser, 1 ±; Dawes, 11–7; $O\Sigma$., 5
1841.41	22.4	22.0	1.63	1.44	+ 0.4	+0.19	4	O. Struve
1842.21	16.6	17.7	1.58	1.60	– 1.1	–0.02	7, 5	Mädler
1842.41	17.1	16.1	1.73	1.67	+ 1.0	+0.06	4, 5	$O\Sigma$., 4–0; Dawes, 0–5
1843.37	12.1	13.7	1.80	1.78	– 1.6	+0.02	17, 12	Mädler, 7; Dawes, 10–5
1844.36	8.9	10.1	2.06	1.97	– 1.2	+0.09	8, 7	Mädler
1845.46	4.5	7.2	2.23	2.15	– 2.7	+0.08	2	O. Struve
1846.59	3.6	4.6	2.21	2.31	– 1.0	–0.10	5	$O\Sigma$., 2; Dawes, 2; Mitchell, 1
1847.38	2.5	3.0	2.40	2.42	– 0.5	–0.02	11	Dawes, 8; $O\Sigma$., 3
1848.34	0.8	1.3	2.71	2.55	– 0.5	+0.16	7, 6	Mädler
1848.40	359.8	1.1	2.57	2.56	– 1.3	+0.01	12	Dawes, 9; $O\Sigma$., 3
1849.37	359.0	359.5	2.84	2.67	– 0.5	+0.17	5, 4	Dawes
1850.40	358.0	357.9	2.74	2.80	+ 0.1	–0.06	11, 4	Jacob, 2–0; $O\Sigma$., 4; Mädler, 1–0; Mädler, 4–0
1851.28	357.9	356.8	2.99	2.90	+ 1.1	+0.09	4	Mädler
1851.40	356.5	356.3	2.99	2.95	+ 0.2	+0.04	5	Dawes
1852.38	354.6	355.4	3.06	3.01	– 0.8	+0.05	7	Dawes, 2; Mädler, 2; $O\Sigma$., 3
1853.30	353.6	354.3	3.21	3.13	– 0.7	+0.08	5, 4	Jacob, 2; Dawes, 3–2
1853.56	353.1	354.0	3.15	3.16	– 0.9	–0.01	12	Mädler, 6; $O\Sigma$., 4; Jacob, 2
1854.43	353.2	353.0	3.22	3.26	+ 0.2	–0.04	15	Dawes, 8; Dembowski, 7
1855.18	351.4	352.3	3.40	3.33	– 0.9	+0.07	8	$O\Sigma$., 4; Dembowski, 4
1855.67	352.8	351.8	3.40	3.40	+ 1.0	0.00	10. 9	Senff, 1; Mädler, 3; Dawes, 4–3; Morton, 3
1856.39	350.5	351.3	3.56	3.44	– 0.8	+0.12	5	Dembowski
1857.28	349.1	350.2	3.70	3.56	– 1.1	+0.14	20	Dembowski, 6; Dawes, 7; Senff, 7
1857.56	350.2	350.1	3.57	3.57	+ 0.1	0.00	22, 21	Mädler, 9–8; Dawes, 6; $O\Sigma$., 2; Jacob, 5
1858.36	349.2	349.3	3.80	3.65	– 0.1	+0.15	8, 6	Dembowski, 6; Mädler, 2–0
1858.44	350.2	349.3	3.59	3.66	+ 0.9	–0.07	16	Senff, 3; $O\Sigma$., 2; Dawes, 8; Morton, 3
1859.36	349.1	348.6	3.83	3.72	+ 0.5	+0.11	24. 23	Morton, 4; Mädler, 9–8; $O\Sigma$., 3; Senff, 3; Dawes, 5
1860.40	347.6	347.6	3.97	3.84	0.0	+0.13	3	Mädler, 1; Knott, 2
1861.23	346.6	347.1	3.93	3.90	– 0.5	+0.03	9	$O\Sigma$., 1; Powell, 5
1861.38	348.1	347.0	4.11	3.91	+ 1.1	+0.20	3 +	Mädler, 3; Auwers —
1862.28	346.0	346.3	4.01	3.99	– 0.3	+0.02	13, 10	Dawes, 5–3; Powell, 3–2; Mädler, 3; $O\Sigma$., 2
1863.51	346.4	345.5	3.99	4.06	+ 0.9	–0.07	28	$O\Sigma$., 2; Dembowski, 26
1864.43	345.3	344.9	4.18	4.14	+ 0.4	+0.04	11	Senff, 2; $O\Sigma$., 3; Dawes, 4; Knott, 2
1865.54	344.2	344.2	4.36	4.22	0 0	+0.14	36, 35	Dawes, 7–6; Knott, 3; Dembowski, 26
1866.36	344.1	343.7	4.34	4.28	+ 0.4	+0.06	5	Senff, 3; $O\Sigma$., 2
1867.80	343.2	342.8	4.30	4.40	+ 0.4	–0.10	12	Dembowski
1868.43	342.2	342.4	4.47	4.45	– 0.2	+0.02	9	O. Struve, 2; Mädler, 7
1869.98	341.8	341.6	4.43	4.53	+ 0.2	–0.10	17	Dunér
1870.74	342.7	341.2	4.54	4.60	+ 0.5	–0.06	14	Dembowski, 11; $O\Sigma$., 3
1871.43	340.5	340.9	4.87	4.65	– 0.4	+0.22	8	Knott, 3; Gledhill, 3; Wilson & Seabroke 2
1872.12	341.1	340.5	4.59	4.68	+ 0.6	–0.09	17	Dunér
1872.63	340.4	340.0	4.61	4.74	+ 0.4	–0.13	13	$O\Sigma$., 3; Dembowski, 10
1873.43	340.3	339.9	4.77	4.76	+ 0.4	+0.01	13	Gledhill, 2; $O\Sigma$., 3; Mädler, 5; Lindstedt, 3
1874.64	340.4	339.3	4.97	4.84	+ 1.1	+0.13	5	Gledhill, 2; $O\Sigma$., 3
1875.18	338.8	339.0	4.76	4.88	– 0.2	–0.12	18	Dunér, 14; Gledhill, 4
1875.36	339.4	338.9	4.83	4.89	+ 0.5	–0.06	25	Dembowski, 11; Schiaparelli, 13
1876.34	339.1	338.5	5.02	4.95	+ 0.6	+0.07	26	Gledhill, 13; Hall, 4; Schiaparelli, 4; Doberck, 5
1877.62	338.0	337.9	4.94	5.01	+ 0.1	–0.07	22	Schiaparelli, 14; Dembowski, 8
1878.37	337.1	337.6	5.06	5.06	– 0.5	0.00	3, 5	Goldney
1879.25	337.9	337.2	5.08	5.12	+ 0.7	–0.04	13	Schiaparelli, 10; Hall, 3
1880 30	337.5	336.8	5.36	5.17	+ 0.7	+0.19	2	Burnham

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
	°		″	″	°	″		
1881.44	336.2	336.3	5.28	5.22	− 0.1	+0.06	14, 17	Hall, 0–4; Big. 14–13
1882.11	336.6	335.9	5.23	5.28	+ 0.1	−0.05	10	Schiaparelli
1883.28	335.6	335.6	5.30	5.31	0.0	−0.01	20, 18	Englemann, 7–5; Hall, 0–5; Schiaparelli 8
1884.38	335.8	335.1	5.34	5.38	+ 0.7	−0.04	17	Hall, 5; Per. 3; Schiaparelli 9
1885.35	334.1	334.8	5.32	5.40	− 0.7	−0.08	19	Copeland, 1; H.C.W., 2; Schiaparelli, 16
1886.36	334.9	334.4	5.15	5.45	+ 0.5	0.00	4, 6	Hall, 4; H.C.W., 0–2
1887.38	334.5	334.0	5.50	5.50	+ 0.5	0.00	11	Schiaparelli, 7; Hall, 4
1888.32	334.1	333.6	5.58	5.55	+ 0.5	+0.03	9	Glas., 2; Hall, 5; Schiaparelli, 2
1889.40	333.4	333.3	5.56	5.60	+ 0.1	−0.04	11	Burnham, 3; Hall, 5; Schiaparelli, 3
1890.43	332.8	332.9	5.59	5.64	− 0.1	−0.05	3	Hall
1891.44	332.5	332.6	5.70	5.67	− 0.1	+0.03	3	See
1892.56	332.3	332.2	5.64	5.71	+ 0.1	−0.07	16	Sch. 6; Leavenw., 2; Comstock, 3; Big. 3; Jones, 2
1893.44	332.2	331.9	5.65	5.75	+ 0.3	−0.10	11, 5	Schiaparelli, 6; Comstock, 1; Big., 4
1894.13	331.1	331.6	5.71	5.79	− 0.5	−0.08	10, 6	Comstock, 2–0; Schiaparelli, 2–0; Big., 6
1895.30	331.1	331.3	5.84	5.83	− 0.2	+0.01	5, 4	See

It will be seen that in this orbit the line of nodes coincides with the minor axis of the real ellipse, which is also the minor axis of its projection: and owing to the small inclination the apparent ellipse is only slightly less eccentric than the real ellipse, so that the foci of the two ellipses very nearly coincide. This renders the motion of the radius vector in the apparent orbit very nearly the same as in the real orbit, and makes γ *Virginis* the best known test-object for the exactness of the law of gravitation in the stellar systems. From direct observation we are enabled to say that the principal star is *very nearly* in the focus of the real ellipse, and that if there is any deviation from the Keplerian law of areas, it must be extremely slight. Therefore the force is certainly central, and if it differs at all from the law of Newton, the deviation must be relatively unimportant. Other researches in double-star astronomy confirm the law of gravitation, and leave no adequate ground for doubt as to its absolute universality. Yet a prolonged study of the motion of γ *Virginis* will eventually not only give a very precise criterion for the rigor of this law, but will also throw light upon the question of the existence of disturbing bodies in binary systems.

The orbit of γ *Virginis* is very remarkable for its high eccentricity, which surpasses that of any other known stellar orbit. This characteristic of γ *Virginis*, which Sir John Herschel recognized when he declared the eccentricity to be "physically speaking, the most important of all the elements" (*Results at Cape of Good Hope*, p. 294), seems to preclude the permanent existence of a third body in the system; for, if a companion to either of the components existed, its motion would be affected by an equation of enormous magnitude, analogous to the annual equation in the moon's motion, and at the time of periastron passage would probably soon cause the body to come into collision with one of the stars, or be driven off in an orbit analogous to a hyperbola.

Thus, although the above orbit is exact to a very high degree, the system will still deserve the occasional attention of astronomers.

Since the angular motion for many years to come will be extremely slow, observations of distance will be more valuable than angular measures in effecting a further improvement of the elements.

This is an appropriate occasion to acknowledge the valuable assistance which has been rendered me in some of the preceding computations by my friend Mr. J. W. Froley, M. Sc., recently a graduate student and Fellow in Astronomy at this University.

The University of Chicago, 1895 *July* 2.

CONFIRMATIONS OF VARIABILITY.

By H. M. PAUL.

— *Librae* = S.DM. −18°3975.

I have observed this new variable, just announced by Mr. Skinner, on five nights. A very rough preliminary reduction of the few observations of the light-scale stars gives the following magnitudes of the variable, which are, relatively, fairly accurate, and in absolute values probably correct within 0M.5.

1895 June 24	11.0 M
24	11.1
July 10	11.4
16	11.6
19	11.7

Haze and moonlight have prevented later observations. Until further data, including perhaps some from the Algiers-Zone observers, are available, the period must remain indeterminate.

H.C.O. SOUTHERN VARIABLES.

Since the appearance of Dr. CHANDLER'S Revised Supplement to his variable-star catalogue [*A.J.* 347], I have endeavored, in compliance with his wish therein expressed, to identify the positions and confirm by direct observation the variability of such of the newly-announced H.C.O. southern variables as are within reach in this latitude and are otherwise unconfirmed. Up to date I am able to give the following results:

5511. *RS Librae.*

For this new variable, which is not in the DM. or the C.DM., I have measured the approximate $\Delta\alpha$ and $\Delta\delta$ from the two preceding DM. $8^M.5$ stars, which are Oeltz.-Arg. S. 14491 and 14501; and the resulting position of the variable is

	h m s	° ′
for 1875.0	15 17 1.8	−22 27.8
giving, for 1900.0	15 18 29.	−22 33.2

Its variability has been confirmed, and the elements determined, by CHANDLER. My recent observations, resulting from an approximate smoothing out of the DM. magnitudes of a few neighboring stars, give

	M
1895 July 17	8.5
19	8.4
28	8.2

7255. *RT Sagittarii.*

My observations, of what I take to be the star intended, are as follows:

	M
1895 July 10	7.7 [bright moonlight]
19	8.1
28	8.2
30	8 2
31	8.2

There is some uncertainty about the position and identity of this star, which should be cleared up. I have tied the star whose magnitudes are given above to Arg. Gen. Catal. 27749 and get the following position:

	h m s	° ′
for 1875.0	20 9 25.5	−39 29.7
giving, for 1900.0	20 11 6	−39 25.2

and thus making it [probably] identical with C.DM. −39°13722 [$9^M.7$] $20^h\ 9^m\ 25^s.1$ −39° 29′.9 [1875.0], although Dr. THOME does not give this among his stars showing discrepancies on different dates.

The original announcement of the variability of this star was made by Mrs. FLEMING in *A.N.* 125:366, where the position for 1900.0 is given as $20^h\ 9^m.4$ −39° 29′, or $-1^m.7$ and −4′ [about 20′] from the position of the star I have observed. This is considerably greater than the radius of inaccuracy indicated by Dr. CHANDLER [*A.J.* 347] as possible in the H.C.O. positions; but it is highly improbable that we have here two new variables 20′ apart.

It is evident that, in the original announcement, the position given, although twice stated to be for 1900.0, is really for 1875.0, this supposition entirely removing the discrepancy.

There is, however, a further point which is of more importance to observers of this star. Close following and north of it is another small one whose coordinates from *RT* [from a rough measure on the only night yet clear enough near the horizon] are approximately $\Delta\alpha$ $+1^s.7$, $\Delta\delta$ $+20''$ [$p = 45°$, $s = 28''$, roughly.]

As nearly as I can judge while *RT* is so much the brighter of the two, the magnitude of this companion is about $10\frac{1}{2}$; but this is very uncertain. As soon as the variable falls to, or below, the companion in brightness, intending observers should tie the latter to neighboring stars of their light-scale, else future confusion may result.

If my estimate of $10\frac{1}{2}$ as the magnitude of the companion is anywhere near the truth, it may be that the photographic magnitude 10.7, measured from the H.C.O. plate of 1889 Oct. 14 [*A.N.* 125:366] refers either to this companion or to the joint light of the two stars.

It is possible also, though much less probable, that one or more estimates of the brightness and position of this companion, instead of *RT*, may have entered into the make-up of Dr. THOME'S C.DM., −39°13722, $9^M.7$. In any case it is evident that the individual observations for this star will be of great service in determining the elements of the variable, and I have written Dr. THOME asking him if he will kindly publish them and any further information that will aid in the matter.

7404. *R Microscopii.*

This star, which appears to be identical with C.DM. −29°17235, $9^M.9$, has diminished rapidly during July. My observations, resulting from an approximate reduction of the light-scale stars on the basis of the C.DM. magnitudes, give

	M
1895 July 9	8.8 [bright moonlight]
19	9.3
28	9.7
30	9.9
31	9.9

To determine a position a little more accurate than that of the C.DM., I have tied the variable to Arg. G.C. 28308, and the resulting position is

	h m s	° ′
for 1875.0	20 32 26.4	−29 13.8
giving, for 1900.0	20 33 58.	−29 8.6

The C.DM. position, which CHANDLER has adopted in his Revised Supplement, is, for 1875.0, $20^h\ 32^m\ 26^s.9$ −29° 13′.7. This star was not included by THOME in his list of those showing discrepancies, but his individual results will be valuable for the determination of the elements.

Washington, 1895 *August* 1.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE DUDLEY OBSERVATORY,

BY A. JAY ROY.

1895 Albany M.T.		$*$	No. comp.	Planet — $*$ $\Delta\alpha$	Planet — $*$ $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
					Planet (372).				
	h m s			m s	′ ″	h m s	° ′ ″		
Feb. 24	10 51 3	1	6	−2 32.07	− 1 14.3	7 41 30.70	+34 23 18.6	9.297	0.182
26	8 24 32	2	6	−0 11.04	− 2 37.5	7 40 53.29	+33 55 21.1	*n*9.053	0.145
Mar. 2	8 1 20	3	7	−1 23.18	− 4 10.9	7 40 0.87	+33 2 58.1	*n*9.102	0.190
3	7 2 0	4	5	−2 24.67	+ 5 1.7	7 39 53.86	+32 50 24.0	*n*9.385	0.276
21	7 37 3	5	5	+1 11.59	+ 0 46.0	7 43 9.97	+29 2 16.4	*n*8.294	0.312
22	7 37 17	6	7	+1 6.45	+ 0 2.0	7 43 37.42	+28 50 13.9	*n*8.062	0.318
					(130) *Electra*.				
Feb. 26	9 49 35	7	6	−0 5.53	+ 1 2.7	9 54 15.46	+14 46 54.7	*n*9.270	0.629
Mar. 14	8 39 23	8	7	+0 23.81	− 2 27.8	9 44 21.56	+16 49 5.9	*n*9.264	0.600
	9 2 36	9	5	−0 27.39	+ 1 4.4	9 44 20.93	+16 49 12.5	*n*9.147	0.593
					(86) *Semele*.				
Mar. 14	9 54 41	10	8	+2 20.86	+ 0 10.8	11 44 54.22	+ 8 49 42.2	*n*9.403	0.705
18	11 20 51	11	5	−2 22.61	+ 2 37.9	11 41 54.50	+ 9 8 39.6	*n*8.828	0.687
30	11 44 50	12	7	−1 40.88	− 6 39.5	11 33 26.20	+ 9 57 7.6	8.952	0.678
					Planet (380).				
April 19	10 32 56	13	7	+1 27.01	+11 51.1	12 50 59.24	+ 4 24 9.3	*n*8.696	0.736
20	10 56 10	13	6	+0 39.96	+15 4.0	12 50 12.19	+ 4 27 22.3	7.546	0.736
23	8 47 8	14	7 , 6	−0 19.71	−12 32.2	12 48 2.57	+ 4 35 17.1	*n*9.316	0.739
28	9 37 31	14	6	−3 46.70	− 1 14.9	12 44 35.59	+ 4 47 4.6	*n*8.878	0.733
May 2	11 47 17	15	6	+2 1.45	− 3 10.5	12 42 6.37	+ 4 53 6.7	9.299	0.736

Mean Places for 1895.0 of Comparison-Stars.

$*$	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	7 44 0.53	+2.24	+34 24 25.7	+ 7.2	Astr. Gesell. Leiden
2	7 41 32.15	+2.18	+33 57 51.1	+ 7.5	Astr. Gesell. Leiden
3	7 41 22.25	+2.10	+33 7 1.5	+ 7.5	Astr. Gesell. Leiden, Paris 9521
4	7 42 16.44	+2.09	+32 45 14.9	+ 7.4	Astr. Gesell. Leiden
5	7 41 56.61	+1.77	+29 1 23.0	+ 7.4	Romberg 1757, etc.
6	7 42 29.22	+1.75	+28 50 4.4	+ 7.5	Romberg 1759, etc.
7	9 54 18.84	+2.15	+14 45 57.4	− 5.4	Astr. Gesell. Leipsic
8	9 43 55.60	+2.15	+16 51 37.7	− 4.0	Astr. Gesell. Berlin
9	9 44 46.17	+2.15	+16 48 12.2	− 4.1	Astr. Gesell. Berlin
10	11 42 31.21	+2.15	+ 8 49 44.0	−12.6	F.4 *Virginis*
11	11 44 14.92	+2.19	+ 9 6 14.3	−12.6	Astr. Gesell. Leipsic. Berlin, etc.
12	11 35 4.86	+2.22	+10 3 58.7	−11.6	Astr. Gesell. Leipsic
13	12 49 29.94	+2.29	+ 4 12 33.5	−15.3	Astr. Gesell. Albany 4602
14	12 48 20.00	{ +2.28 { +2.29	+ 4 48 31.1	{ −14.8 { −14.6	Astr. Gesell. Albany 4596
15	12 40 2.64	+2.28	+ 4 56 31.3	−14.1	Astr. Gesell. Albany 4560

For the positions in the Berlin and Leipsic zones, I am indebted to the kindness of Dr. AUWERS and Dr. BRUNS.

NEW VARIABLE NEAR *S VELORUM*.

BY ALEX. WM. ROBERTS.

$\alpha = 9^{\mathrm{h}}\ 28^{\mathrm{m}}\ 31^{\mathrm{s}}$ (1875). $\delta = 44°\ 57'\ 41''$.

The star Cordoba Z.C. IX, 2301, used as a comparison-star for *S Velorum* (*Astr. Journal* no. 327, p. 111, table III), is itself variable between the limits 8.1 and 8.5 mags. The following are the measures made in the present year:

	Mag.	No. obs.
1895 Feb. 28.35	8.15	1
Mar. 2.33	8.15	2
4.37	8.25	1
12.31	8.35	1
15.35	8.35	1
29.42	8.55	21
April 3.45	8.55	1
16.27	8.30	1
19.41	8.20	1
26.47	8.10	1
27.37	8.15	1
May 10.46	8.15	1
16.42	8.18	12
27.34	8.25	10
28.35	8.35	1
29.31	8.35	1
1895 May 31.39	8.35	1
June 10.31	8.45	1
11.31	8.48	2
14.37	8.42	2
15.33	8.35	1
17.36	8.40	1
18.31	8.40	1
19.31	8.30	1
20.35	8.30	3
21.32	8.25	1
22.40	8.20	1
25.32	8.15	1
26.33	8.20	4
27.33	8.05	1
28.26	8.10	1

Each observation is the mean of two measures, one with a direct and the other with a reversing eye piece; only two comparison-stars were used.

Cord. Z.C., IX. 2157	Mag.	8.05
2429		8.35

and the latter of these two stars seems to fluctuate between 8.30 and 8.45. Notwithstanding this slight uncertainty, there can be no doubt as to actual and regular variation of Z.C. IX, 2301 between the assigned limits, in a period of about 65 days.

The rise to maximum is only half as long as the fall to minimum. I regret that I have been unable to secure any observations of either this star or *S Velorum* during January and February of the present year, but the weather during these months was exceedingly unfavorable.

NEW VARIABLE IN LIBRA, S.DM. —18°3975,

$14^{h}\ 58^{m}\ 14^{s}.7$, —18° 10′.1 (1855).

By AARON N. SKINNER, Assistant Astronomer.

[Communicated by Prof. Wm. Harkness, Astronomical Director, Naval Observatory.]

In the course of the observation of the Washington Zone —13° 50′ to —18° 10′ I have found difficulty in securing a second observation of S.DM. —18°3975 on account of its faintness. This led me to compare the different estimates of three adjacent stars including —18°3975, to determine whether the star in question has suffered a change in brightness. The estimates are as follows:

	Schönfeld	Skinner '94 July 22	 '95 June 10	 '95 June 22
	M	M	M	M
S.DM. —18°3965	9.0	9.1	9.1	9.2
S.DM. —18°3969	8.7	8.9	8.8	9.0
S.DM. —18°3975	9.0	8.7	"too faint"	invisible, prob. <10.5 mag.

The instrument employed was the 9-inch transit-circle, in which the limit for observing with bright field is $10^{M}.0$

The above comparisons show plainly a decrease in brightness of probably two magnitudes between 1894 July 22 and 1895 June 22 of S.DM. —18°3975.

Through the courtesy of Dr. Küstner, Director of the Bonn Observatory, I have received additional evidence of variability from the Bonn observations. I quote from Dr. Küstner's letter.

"Ueber den Ort von —18°3975 sind folgende Durchmusterungs Zonen gegangen. Ich füge dabei gleich hinzu die Beobachtungen des benachbarten Sternes —18°3976, da diese zum Vergleich zu beachten sind.

1) Schönfeld (am 6-Zöller), Zone 180, 1877 April 20, Mondschein und gute Beleuchtung. Meist sehr schöne Luft.

	M	h m s	° ′
—18°3975	8.5	14 58 14.7	—18 10.1
—18°3976	9.5	58 46.8	—18 6.5

2) Schönfeld (am 6-Zöller), Zone 532, 1880 Mai 1, Meist sehr klare Luft, matte Beleuchtung.

—18°3975 nicht beobachtet, trotz dem, gengend Zeit vorhanden.
—18°3976 10^{M} $14^{h}\ 58^{m}\ 46^{s}.4$ —18° 6′.2

Der Stern —18°3975 is demnach an diesem Tage wahrscheinlich schwächer gewesen als —18°3976: sein Fehlen ist jedenfalls auffallend. Seine Existenz am Himmel nahm Schönfeld für gesichert an, da er auch in einer der früheren von Thormann am Cometensucher der Nördlichen Durchmusterung beobachteten Zonen vorkommt.

3) Thormann (am 3-Zöller), Zone 144, 1853 Mai 5.

—18°3975 9^{M} $14^{h}\ 58^{m}\ 13^{s}$ —18° 11′.1
—18°3976 fehlt, was aber hier an dem kleinen Instrumente nicht auffallend."

This star is within the limits of the Algiers zone, and I expect soon to receive from Director Trépied his estimates of the magnitude of this star.

Washington, D.C., 1895 *Aug.* 2.

ON THE LIGHT-CURVE OF 103 *T ANDROMEDAE*,

By HENRY M. PARKHURST.

In the paper of Mr. Yendell in *A.J.* No. 348, and in the accompanying diagram, he has omitted to include my observations, given in No. 347, evidently for the reason that they are given in photometric magnitudes, and therefore need reduction to his scale. Unfortunately I have only measured the first three of his eight comparison-stars, and my observations agree with the DM. estimates in making his star *a* brighter than *b*. It is therefore impossible to transfer from one scale to the other with accuracy at present. Comparing his third star with the mean of the first two, I have obtained an approximate formula by means of which I have reduced my ten observations from Oct. 20 to Dec. 31 to his scale, showing an average deviation of $0^{M}.11$ from the curve of his diagram.

In the absence of photometric results it is conceivable that a scale founded upon mere estimation should be so distorted that a linear light-curve would apparently become curvilinear. I have therefore plotted my observations upon the photometric scale, first in magnitudes, and second in photometric light-units, with the result that each shows a marked curvilinear form. It is unnecessary to reproduce these drawings, for it is easy to judge of the influence of the scale upon the observations by another method. Referring to Yendell's drawing, the only possible question is as to the correctness of the vertical scale. We have only to imagine the diagram printed upon an elastic surface, and expanded, where it is necessary, by a minute fraction. It is manifest that there would be no appreciable approach to the linear form of the light-curve near the vertex. The column of light-units for the comparison stars, involving the other mode of representation, does not appear to be used in the formation of the curve.

Mr. Yendell has evidently overlooked my description (contained in H.C.O. Annals, vol. xviii), of my own photometric apparatus, with which all the photometric observations reported in my "Notes on Variable Stars" are made; for my observations with the deflector do not depend upon the comparison of two images. Each star is extinguished precisely as with the wedge; but the deflector avoids important sources of error in the wedge, as I have elsewhere indicated. [H.C.O. Annals, vol. xxix.]

NEW COMET.

A faint comet is announced by Swift:

Aug. 20.9167 Greenw. M.T. $\alpha = 6^\circ\ 55'$, $\delta = +5^\circ\ 30'$.

He describes it as round, and moving slowly in the direction north following.

COMET *a* 1895 (*SWIFT*),

Observations have been telegraphically received, made by Prof. Barnard at Mt. Hamilton, Aug. 21, Prof. Wilson at Northfield, Aug. 23; also two later ones at Albany by Prof. Boss, Aug. 24 and 25. They are:

1895		h m s	° ′ ″
Aug. 21.8127	Greenw. M.T.	0 30 11.4	+5 38 55
23.8954	" "	0 35 3.6	5 48 49
24	12h 58m 22s Alb. M.T.	0 37 0.66	5 52 17.0
25	13h 17m 14s " "	0 39 16.94	+5 56 2.2

ELEMENTS AND EPHEMERIS OF COMET *a* 1895 (*SWIFT*),

By LEWIS BOSS.

Combining an observation made at the Dudley Observatory, Aug. 25, with others received by telegraph, made at the Lick Observatory Aug. 21, and at the Goodsell Observatory, Northfield, Aug. 23, the following elements are derived.

$$T = 1895 \text{ Aug. } 24.536 \text{ Greenw. M.T.}$$

$$\left.\begin{array}{rl} \omega = & 171^\circ\ 27'.8 \\ \Omega = & 172\ \ 51.0 \\ i = & 4\ \ \ 9.9 \end{array}\right\} \text{App. Equin.}$$

$$\log q = 0.15736$$

Comparison of computed and observed places for Aug. 23 (C−O): $\Delta\lambda = -7''$; $\Delta\beta = +2''$. The inclination points to the probable periodic character of this comet, but these elements are otherwise necessarily very uncertain. Olbers's method is not applicable to this case.

Ephemeris for Greenwich Midnight.

1895	App. α h m s	App. δ ° ′	log. Δ	Brightn.
Aug. 29.5	0 47 17	+6 6.7	9.7092	1.04
Sept. 2.5	0 55 17	+6 13.0	9.7074	1.05
6.5	1 2 36	+6 14.3	9.7110	1.04
10.5	1 9 8	+6 10.8	9.7218	1.01
14.5	1 14 55	+6 3.4	9.7336	0.99
18.5	1 19 54	+5 52.6	9.7528	0.94

CORRIGENDA.

No. 351, p. 115, l. 7, *for* $(V-\varpi-2\tau')$, *put* $(V-\omega-2\tau')$: l. 8 *for* $(V-\omega'-2\tau')$ *put* $(V-\varpi'-2\tau')$.

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Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office at Boston, Mass., as second-class matter. *Closed August* 28.

THE

ASTRONOMICAL JOURNAL.

No. 353.

VOL. XV. BOSTON, 1895 SEPTEMBER 7. NO. 17

THE PERIODIC SOLUTION AS A FIRST APPROXIMATION IN THE LUNAR THEORY.

By G. W. HILL.

The lunar theory may be developed in either of two ways. In the first, the coefficients of the periodic terms in the expressions for the coordinates are exhibited as functions of the elements on which they depend, the latter being left indeterminate. This may be called a literal lunar theory. In the second certain numerical values are attributed to these elements at the beginning even of the investigation, and all the following computations are performed on numerical quantities so that the final results present the mentioned coefficients in the form of numbers. This may be called a numerical lunar theory. Both these methods of treatment are to be desired; the former having the greater attraction for the mathematician; while the latter recommends itself to the practical astronomer who wishes merely to have the power of predicting the position of the moon. The latter is also preferable on account of the far less labor required for its elaboration. A literal theory probably demands from four to six times as much labor as suffices for a numerical theory. The latter indeed has the disadvantage of depending on values of the elements which afterwards may be discovered to need correction; however, this objection is of very slight weight since the literal theories we already possess are amply sufficient for assigning the corresponding corrections of the coefficients.

Nearly all the lunar theories in existence have been elaborated by successive steps of approximation in which the elliptic theory has been taken as the starting point. It may be asked whether some labor may not be saved by adopting as the first approximation the best values attainable for the coordinates.

It is well known that the problem of three bodies admits a periodic solution in which the motions of the two planets about the body, considered as central, take place in the same plane, and where the eccentricities peculiar to each planet vanish. It is the object of the present article to elaborate this solution in the case of the moon, employing the numerical method. It is very desirable that the approximation in this solution should be pushed to a high degree of precision, much more than at first sight would seem at all necessary, because, in the further elaboration of the lunar theory by this method, the motions of the perigee and node depend on the values here assigned to the coefficients of the periodic terms.

In the particular solution just mentioned there are only four independent arbitrary constants introduced by integration. Two of these simply define the phases of the planets at the origin of time, while the remaining two may be taken to be the average rates of increase of their longitudes. These four constants may be denoted in their order as ε, ε', n, n'. It is expedient to eliminate the masses of the bodies from the equations by introducing two constants to take their places; these we denote by the symbols a, a'. The masses of the sun, earth and moon being severally denoted by m_1, m_2 and m_3, the mentioned constants are connected by the equations

$$m_1 + m_2 + m_3 = M = a'^3 n'^2, \qquad m_2 + m_3 = a^3 n^2$$

For convenience we adopt the notations

$$\mu = \frac{m_3}{m_2 + m_3} \quad , \quad \mu' = \frac{m_2 + m_3}{m_1 + m_2 + m_3}$$

For properly exhibiting the effect of the moon's mass on its motion relative to the earth, the system of coordinates, where the moon is referred to the earth, but the sun to the center of gravity of the earth and moon, is well adapted. Denoting such rectangular coordinates together with the radii as x, y, r for the moon, and x', y', r' for the sun, it is well known that the differential equations of motion are

$$m_2\mu \frac{d^2x}{dt^2} = \frac{\partial\Omega}{\partial x} \qquad m_2\mu \frac{d^2y}{dt^2} = \frac{\partial\Omega}{\partial y}$$

$$m_1\mu' \frac{d^2x'}{dt^2} = \frac{\partial\Omega}{\partial x'} \qquad m_1\mu' \frac{d^2y'}{dt^2} = \frac{\partial\Omega}{\partial y'}$$

where Ω, the potential function, is equal to the sum of the products of every two masses into the reciprocal of their distance, or

$$\Omega = \frac{m_1 m_2}{\Delta_{1,2}} + \frac{m_1 m_3}{\Delta_{1,3}} + \frac{m_2 m_3}{\Delta_{2,3}}$$

The distances are given in terms of the coordinates by the equations

$$\Delta_{1,2}^2 = (x'+\mu x)^2 + (y'+\mu y)^2$$
$$\Delta_{1,3}^2 = [x'-(1-\mu)x]^2 + [y'-(1-\mu)y]^2$$
$$\Delta_{2,3}^2 = x^2 + y^2 = r^2$$

The ratio $\left(\frac{r}{r'}\right)$ is so small that it is advisable to develop Ω in a series of its powers. Thus is obtained as a suitable potential for the determination of the moon's coordinates

$$\begin{aligned}\frac{1}{m_2\mu}\,\Omega = \frac{m_2+m_3}{r} + m_1 \Big\{ & [(1-\mu)^{-1}+\mu^{-1}]\frac{1}{r'} \\ & + [(1-\mu)+\mu]\frac{r^2}{r'^3}(\tfrac{3}{2}S^2-\tfrac{1}{2}) \\ & + [(1-\mu)^2-\mu^2]\frac{r^3}{r'^4}(\tfrac{5}{2}S^3-\tfrac{3}{2}S) \\ & + [(1-\mu)^3+\mu^3]\frac{r^4}{r'^5}(\tfrac{35}{8}S^4-\tfrac{15}{4}S^2+\tfrac{3}{8}) \\ & + [(1-\mu)^4-\mu^4]\frac{r^5}{r'^6}(\tfrac{63}{8}S^5-\tfrac{35}{4}S^3+\tfrac{15}{8}S) \\ & + \;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\; \Big\}\end{aligned}$$

S being determined by the equation

$$rr'S = xx' + yy'$$

To get the similar function for the relative motion of the sun about the center of gravity of the earth and moon it is only necessary to multiply the preceding expression by

$$\frac{m_2\mu}{m_1\mu'} = \frac{M}{m_1}\mu(1-\mu)$$

Here, neglecting the first term as independent of solar coordinates, it will suffice to take the two next following and write

$$\frac{1}{m_1\mu'}\,\Omega = \frac{M}{r'} + M\mu(1-\mu)\frac{r^2}{r'^3}(\tfrac{3}{2}S^2-\tfrac{1}{2})$$

For our purpose it is sufficiently accurate to suppose that the motion of the sun about the center of gravity of the earth and moon is circular and uniform. The various inequalities have coefficients less than 0″.0002, and it is easy to see that the effect of neglecting them on the position of the moon is much less than this quantity. Therefore, in the last expression, we can substitute for $\frac{r^2}{r'^3}(\tfrac{3}{2}S^2-\tfrac{1}{2})$ its non-periodic term. Here a rude approximation suffices, and, turning to PONTÉCOULANT. *Théorie Analytique du Système du Monde*, Tom. IV, p. 100, we find that this non-periodic term is

$$\frac{a^2}{a'^3}\left[\tfrac{1}{4} - \tfrac{179}{96}m^2 - \tfrac{97}{16}m^3 - \tfrac{7681}{576}m^4 - \tfrac{7103}{288}m^5 - \tfrac{14028053}{331776}m^6\right]$$

m denoting the ratio of the month to the year. Thus, putting

$$K = \mu(1-\mu)\frac{a^2}{a'^2}\left[\tfrac{1}{4} - \tfrac{179}{96}m^2 - \tfrac{97}{16}m^3 - \;.\;.\;.\;\right]$$

we may take for the motion of the sun

$$\frac{1}{m_1\mu'}\,\Omega = \frac{M}{r'}\left[1 + K\frac{a'^2}{r'^2}\right].$$

Employing λ' to denote the longitude, the solar differential equations of motions are

$$\frac{d^2r'}{dt^2} - r'\frac{d\lambda'^2}{dt^2} + \frac{M}{r'^2} + 3MK\frac{a'^2}{r'^4} = 0$$
$$\frac{d\lambda'}{dt} = n'$$

As K is an excessively small quantity its square may be neglected, and the differential equations are satisfied by the values

$$r' = a'(1+K) \quad , \quad \lambda' = \varepsilon' + n't$$

Certain modifications can now be made in the differential equations for the coordinates of the moon. Denoting the longitude by λ, let $\phi = \lambda - \lambda'$, and let τ denote the mean value of the same, so that $\tau = \varepsilon - \varepsilon' + (n-n')t$. Making τ the independent variable instead of t, and putting

$$\mathrm{m} = \frac{n'}{n-n'} \quad , \quad R = \frac{1}{m_2\mu(n-n')^2}\,\Omega$$

and adopting r and ϕ as the variables for expressing the position of the moon, the differential equations become

$$\frac{d^2r}{d\tau^2} - r\left(\frac{d\phi}{d\tau} + \mathrm{m}\right)^2 = \frac{\partial R}{\partial r}$$
$$\frac{d}{d\tau}\left[r^2\left(\frac{d\phi}{d\tau} + \mathrm{m}\right)\right] = \frac{\partial R}{\partial \phi}$$

As R now contains no variables but r and ϕ, r' being constant, if we multiply these equations severally by dr and $d\phi$, and add the resulting equations we have an exact differential, which, being integrated, gives

$$\frac{dr^2 + r^2d\phi^2}{d\tau^2} = 2R + \mathrm{m}^2r^2 + 2C$$

C being the arbitrary constant. This equation can be substituted for the second of the former, and, if we put

$$a^2V = 2R + \mathrm{m}^2r^2 + 2C$$

the two equations of the problem can take the form

$$\frac{d^2r^2}{a^2d\tau^2} - 4\mathrm{m}\frac{r^2}{a^2}\frac{d\phi}{dt} = 2V + r\frac{\partial V}{\partial r}$$
$$\frac{dr^2 + r^2d\phi^2}{a^2d\tau^2} = V$$

By making ϕ the independent variable we shall obtain the advantage of having but one equation to integrate. We adopt r^2 as the unknown to be determined, and, as $\frac{r^2}{a^2}$ differs from unity by a small quantity, we put $\frac{r^2}{a^2} = 1 + u$. Also, for the same reason, we put $\frac{d\tau}{d\phi} = 1 + v$. Then our equations may be written

$$\frac{d}{d\phi}\left[\frac{1}{1+v}\,\frac{du}{d\phi}\right] - 4\mathrm{m}(1+u) = (1+v)\left(2V + r\frac{\partial V}{\partial r}\right)$$
$$1 + u + \frac{1}{4(1+u)}\frac{du^2}{d\phi^2} = (1+v)^2V$$

In order to have small quantities to deal with we put

$$V = 1 + N \quad , \quad 2V + r\frac{\partial V}{\partial r} = U - 4\mathrm{m}$$

N and U are then of the same order of smallness as m^2. Then the equations which solve the problem are

$$(1+r)^2 = \frac{1+u+\dfrac{1}{4(1+u)}\dfrac{du^2}{d\phi^2}}{1+N}$$

$$\frac{d}{d\phi}\left[\frac{1}{1+r}\,\frac{du}{d\phi}\right]-4\mathrm{m}(u-r) = (1+r)\,U$$

$$\tau = \phi+\int r\,d\phi$$

It is plain that the arbitrary constant C, which enters into the expression for V and thus into those for N and U, is not independent of those which have already been noted, viz.: a, a', n, n'; but, in the numerical method, we do not need to know its expression in terms of the latter, we simply assign to it such a numerical value as will make the non-periodic term of r vanish in the periodic development of the latter as a function of ϕ. As $\frac{2C}{a^2}$ is nearly equivalent to -1, the expressions for N and U will be simplified if we replace it by

$$1-\mathrm{m}^2-2(1+\mathrm{m})^2+C$$

where the new C is a quantity of the order of m^2.

With these modifications, if we adopt the following notation for certain constants,

$$\alpha_1 = (1-\mu')\,\mathrm{m}^2\frac{a'^3}{r'^3}$$

$$\alpha_2 = (1-\mu')(1-2\mu)\,\mathrm{m}^2\frac{a}{a'}\frac{a'^4}{r'^4}$$

$$\alpha_3 = (1-\mu')(1-3\mu+3\mu^2)\,\mathrm{m}^2\frac{a^2}{a'^2}\frac{a'^5}{r'^5}$$

$$\alpha_4 = (1-\mu')(1-4\mu+6\mu^2-4\mu^3)\,\mathrm{m}^2\frac{a^3}{a'^3}\frac{a'^6}{r'^6}$$

the expressions of the functions N and U, in terms of u and ϕ, are

$$\begin{aligned}N = {} & C+2(1+\mathrm{m})^2[(1+u)^{-1/2}-1]+\mathrm{m}^2u\\ & +\alpha_1(1+u)[\tfrac{3}{2}\cos 2\phi+\tfrac{1}{2}]\\ & +\alpha_2(1+u)^{3/2}[\tfrac{5}{4}\cos 3\phi+\tfrac{3}{4}\cos\phi]\\ & +\alpha_3(1+u)^2[\tfrac{35}{32}\cos 4\phi+\tfrac{5}{8}\cos 2\phi+\tfrac{9}{32}]\\ & +\alpha_4(1+u)^{5/2}[\tfrac{63}{64}\cos 5\phi+\tfrac{35}{64}\cos 3\phi+\tfrac{15}{32}\cos\phi]\\ & +\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\end{aligned}$$

$$\begin{aligned}U = {} & 2C+2(1+\mathrm{m})^2[(1+u)^{-1/2}-1]+4\mathrm{m}^2u\\ & +4\alpha_1(1+u)[\tfrac{3}{2}\cos 2\phi+\tfrac{1}{2}]\\ & +5\alpha_2(1+u)^{3/2}[\tfrac{5}{4}\cos 3\phi+\tfrac{3}{4}\cos\phi]\\ & +6\alpha_3(1+u)^2[\tfrac{35}{32}\cos 4\phi+\tfrac{5}{8}\cos 2\phi+\tfrac{9}{32}]\\ & +7\alpha_4(1+u)^{5/2}[\tfrac{63}{64}\cos 5\phi+\tfrac{35}{64}\cos 3\phi+\tfrac{15}{32}\cos\phi]\\ & +\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\end{aligned}$$

From these expressions it will be seen that if the numerical value of N has been obtained through the first, that of U immediately results by summing the several terms of N multiplied by simple integers.

The coefficients in the periodic solution here treated are functions of three independent constants, which may be taken to be m, $\frac{a}{a'}$ and μ. The values we assign to them are

$$\mathrm{m} = 0.08081\,89338\,, \quad \frac{a}{a'} = 0.00257\,3603\,, \quad \mu = \tfrac{1}{82.5}$$

The first is so approximate that it will scarcely need correction. The second corresponds to the value 8″.8 of the constant of the solar parallax, which is adopted simply because it is a round number. The third, which results from the principal constants of nutation and precession, is about as close a value as at present can be assigned to this constant and at the same time be expressed in few figures. The connected constants, which are functions of these, have the values:

$$\mu' = \tfrac{1}{328242.3}\,, \quad K = 0.00000\,00188$$

$$\alpha_1 = 0.00653\,65298\,16$$

$$\alpha_2 = 0.00001\,64146\,16$$

$$\alpha_3 = 0.00000\,00417\,39$$

$$\alpha_4 = 0.00000\,00001\,06$$

The approximate value of u, to be substituted in the differential equations, and afterwards corrected, will be obtained from the results given by Mr. ERNEST W. BROWN and myself (*Amer. Jour. Math.*, Vols. I and XIV). After correcting the numbers to make them correspond to the adopted moon's mass and the constant of solar parallax, we have

$$\frac{a_0}{a} = 0.99909\,30780$$

$$\frac{r}{a_0}\cos(\phi-\tau) = \left\{\begin{array}{rl}1+0.00028\,81665 & \cos\tau\\ -0.00718\,00404 & \cos 2\tau\\ -0.00000\,75187 & \cos 3\tau\\ +0.00000\,60337 & \cos 4\tau\\ -0.00000\,00034 & \cos 5\tau\\ +0.00000\,00326 & \cos 6\tau\\ 0.00000\,00000 & \cos 7\tau\\ +0.00000\,00002 & \cos 8\tau\end{array}\right\}$$

$$\frac{r}{a_0}\sin(\phi-\tau) = \left\{\begin{array}{rl}-0.00061\,02619 & \sin\tau\\ +0.01021\,15492 & \sin 2\tau\\ +0.00000\,72231 & \sin 3\tau\\ +0.00000\,57245 & \sin 4\tau\\ +0.00000\,00058 & \sin 5\tau\\ +0.00000\,00275 & \sin 6\tau\\ 0.00000\,00000 & \sin 7\tau\\ +0.00000\,00002 & \sin 8\tau\end{array}\right\}$$

By computing the special values of these functions and thence those of $\frac{r^2}{a^2}$ and $\phi-\tau$ for the thirteen values of τ evenly distributed from 0° to 180°, and then applying the formulas for deriving periodic series from special values to the latter, we get

$$u = \frac{r^2}{a^2}-1 = \left\{\begin{array}{rl}0.00173\,50214 & \\ +0.00056\,71290 & \cos\tau\\ -0.01433\,41815 & \cos 2\tau\\ -0.00001\,08564 & \cos 3\tau\\ -0.00001\,42655 & \cos 4\tau\\ -0.00000\,00213 & \cos 5\tau\\ -0.00000\,00366 & \cos 6\tau\\ -0.00000\,00004 & \cos 7\tau\\ 0.00000\,00000 & \cos 8\tau\end{array}\right\}$$

$$\phi - \tau = \left\{\begin{array}{rl} -\;\;125''.72648 & \sin \tau \\ +2106.27394 & \sin 2\tau \\ +\;\;\;\;\;0.73663 & \sin 3\tau \\ +\;\;\;\;\;8.74177 & \sin 4\tau \\ +\;\;\;\;\;0.00765 & \sin 5\tau \\ +\;\;\;\;\;0.04898 & \sin 6\tau \\ +\;\;\;\;\;0.00008 & \sin 7\tau \\ +\;\;\;\;\;0.00031 & \sin 8\tau \end{array}\right\}$$

The second of these equations must now be reversed so as to exhibit τ as a function of ϕ, and the right member of the first changed into a function of the same variable. This is accomplished through the method of special values, or by an application of LAGRANGE's Theorem. For convenience, exhibiting the first in terms of the radian, we get

$$\tau = \phi + \left\{\begin{array}{rl} +0.00061\,26473 & \sin \phi \\ -0.01021\,12121 & \sin 2\phi \\ -0.00001\,29397 & \sin 3\phi \\ +0.00006\,18797 & \sin 4\phi \\ +0.00000\,01885 & \sin 5\phi \\ -0.00000\,05352 & \sin 6\phi \\ -0.00000\,00028 & \sin 7\phi \\ +0.00000\,00055 & \sin 8\phi \end{array}\right\}$$

$$u = \left\{\begin{array}{rl} -0.00188\,15691 & \\ +0.00057\,84401 & \cos \phi \\ -0.01433\,26460 & \cos 2\phi \\ -0.00002\,26099 & \cos 3\phi \\ +0.00013\,20733 & \cos 4\phi \\ +0.00000\,04284 & \cos 5\phi \\ -0.00000\,13789 & \cos 6\phi \\ -0.00000\,00070 & \cos 7\phi \\ +0.00000\,00156 & \cos 8\phi \end{array}\right\}$$

From the latter equation we derive the following special values of u and its differential, the first to 11 decimals, the second to 10.

ϕ	u	$\frac{du}{d\phi}$
0°	−1552 72535 0	0
15	−1368 51204 8	+1377 95258
30	− 861 19787 7	+2414 49781
45	− 158 89281 4	+2829 74425
60	+ 552 93712 0	+2478 32319
75	+1076 30147 8	+1419 13080
90	+1258 45447 0	− 64 84608
105	+1013 07758 0	−1540 57776
120	+ 490 52899 0	−2578 13247
135	− 243 83254 6	−2901 65947
150	− 961 31365 3	−2458 99497
165	−1477 08311 0	−1398 70662
180	−1663 97567 0	0

In order to make r have 0 for its non-periodic term, we discover that the proper value for our second C is −0.00691 79735 5. With this value we determine the values of N with 11 decimals and of r with 10, as follow:

ϕ	N	r
0°	+2423 62364 7	−1960 34362
15	+2077 04404 1	−1699 81270
30	+1126 28190 9	− 980 20757
45	− 181 26557 4	+ 21 24791
60	−1497 24415 9	+1042 98444
75	−2461 13925 6	+1799 70812
90	−2801 88479 9	+2067 32850
105	−2420 67794 5	+1762 32100
120	−1422 31459 5	+ 973 86650
135	− 81 41117 5	− 70 74302
150	+1241 28206 1	−1086 15603
165	+2199 48222 6	−1812 72120
180	+2548 20012 6	−2075 28823

The values of U with 11 decimals are:

ϕ	U
0°	+5575 26677 1
15	+4848 34346 5
30	+2851 89637 7
45	+ 100 41000 3
60	−2676 95407 9
75	−4720 17206 3
90	−5454 62497 2
105	−4670 63959 3
120	−2591 36210 6
135	+ 202 39483 6
150	+2954 06634 9
165	+4944 15126 9
180	+5667 66586 5

When these values are substituted in the differential equation

$$\frac{d}{d\phi}\left[\frac{1}{1+r}\,\frac{du}{d\phi}\right] - 4m(u-r) - (1+r)U = 0$$

the left member, instead of becoming 0, takes the value, in the periodic form,

$$138 + 171.0 \cos\phi + 1270 \cos 2\phi - 214 \cos 3\phi + 100 \cos 4\phi$$
$$- 23 \cos 5\phi - 44 \cos 6\phi - 3 \cos 7\phi - 62 \cos 8\phi.$$

where the coefficients are noted in units of the 10th decimal.

A second trial has been made with this differential equation by substituting in it the value

$$u = \left\{\begin{array}{rl} -0.00188\,16351 & \\ +0.00057\,82699 & \cos \phi \\ -0.01433\,26793 & \cos 2\phi \\ -0.00002\,26122 & \cos 3\phi \\ +0.00013\,20725 & \cos 4\phi \\ +0.00000\,04277 & \cos 5\phi \\ -0.00000\,13727 & \cos 6\phi \\ -0.00000\,00070 & \cos 7\phi \\ +0.00000\,00153 & \cos 8\phi \\ +0.00000\,00001 & \cos 9\phi \\ -0.00000\,00002 & \cos 10\phi \end{array}\right\}$$

Precisely as in the first trial it is found that $C =$ −0.00691 81146 9, and that r, in units of the 11th decimal, has the special values

ϕ	r
0°	−1960 36519 9
15	−1699 83366 4
30	− 980 22578 1
45	+ 21 23523 8

ϕ	r
60°	+1042 97800 8
75	+1799 70665 7
90	+2067 33150 0
105	+1762 32890 1
120	+ 973 87813 5
135	− 70 73027 3
150	−1086 14268 3
165	−1812 70686 1
180	−2075 27315 3

The value of the left member of the differential equation. instead of becoming 0, is, in the developed periodic form (the coefficients in units of the 11th decimal)

$$
\begin{aligned}
&+27426+37\cos\phi+21763\cos 2\phi+1818\cos 3\phi\\
&+2707\cos 4\phi+1501\cos 5\phi-21995\cos 6\phi\\
&-27\cos 7\phi+969\cos 8\phi+63\cos 9\phi+182\cos 10\phi
\end{aligned}
$$

In order to discover the correction of the substituted value, it is necessary to form the equations to *variation* of the two differential equations of the problem. Here we must attribute a variation δC to the constant C as well as the variation δu to u. Differentiating the expressions for N and U with respect to u we get as the special values

ϕ	$\frac{dN}{du}$	$\frac{dU}{du}$
0°	−1.17634	−1.11732
15	1.17433	1.11928
30	1.16878	1.12460
45	1.16126	1.13188
60	1.15375	1.13914
75	1.14836	1.14449
90	1.14654	1.14654
105	1.14888	1.14487
120	1.15478	1.13999
135	1.16273	1.13329
150	1.17062	1.12656
165	1.17636	1.12163
180	−1.17848	−1.11984

From these are readily determined the special values of δr, and, if we put

$$\delta r = F\delta C + G\delta u + H\frac{d.\delta u}{d\phi}$$

ϕ	F	G	H
0°	−0.47860	+1.06092	0
15	0.48150	1.06374	+0.00348
30	0.48959	1.07154	0.00608
45	0.50101	1.08251	0.00710
60	0.51290	1.09103	0.00619
75	0.52184	1.10281	+0.00353
90	0.52505	1.10599	−0.00016
105	0.52144	1.10257	0.00384
120	0.51216	1.09367	0.00644
135	0.50006	1.08209	0.00728
150	0.48851	1.07108	0.00620
165	0.48038	1.06334	−0.00354
180	−0.47746	+1.06057	0

By writing the variation of the differential equation thus

$$\frac{d}{d\phi}\left[\frac{1}{1+r}\,\frac{d.\delta u}{d\phi}-\frac{1}{(1+r)^2}\,\frac{du}{d\phi}\,\delta r\right] = L\delta C + M\delta u + P\frac{d.\delta u}{d\phi}$$

we get

ϕ	L	M	P
0°	+2.0884	−1.05596	0
15	2.0984	1.06930	−0.00096
30	2.1248	1.10615	0.00179
45	2.1620	1.15771	0.00229
60	2.2005	1.21071	0.00217
75	2.2294	1.25039	−0.00131
90	2.2398	1.26483	+0.00006
105	2.2282	1.24971	0.00142
120	2.1984	1.20971	0.00225
135	2.1593	1.15685	0.00234
150	2.1218	1.10567	0.00182
165	2.0953	1.06921	+0.00097
180	+2.0858	−1.05608	0

By substituting the periodic developments which correspond to the special values, this equation may be reduced to the form

$$
\begin{aligned}
&[1.00010-62\cos\phi+2043\cos 2\phi+3\cos 3\phi+6\cos 4\phi]\frac{d^2\delta u}{d\phi^2}\\
+\;&[121\sin\phi-6957\sin 2\phi-12\sin 3\phi-20\sin 4\phi]\frac{d.\delta u}{d\phi}\\
+\;&[1.15885+93\cos\phi-16644\cos 2\phi-45\cos 3\phi+266\cos 4\phi]\,\delta u\\
=\;&[2.16208+137\cos\phi-10493\cos 2\phi-35\cos 3\phi+268\cos 4\phi]\,\delta C\\
+\;&\text{residual},
\end{aligned}
$$

in which the numerical coefficients are all to five places of decimals. In this we substitute the periodic series with indeterminate coefficients

$$\delta u = a_0 + a_1\cos\phi + a_2\cos 2\phi + a_3\cos 3\phi + \ldots$$

and equate to zero each coefficient of the cosine of the multiple of ϕ, and thus obtain a group of equations determining the a. As the non-periodic term of δr should vanish, this furnishes the equation determining δC,

$$-0.50104\,\delta C+1.08284a_0+20a_1-1849a_2-6a_3+47a_4 = 0$$

where again the coefficients have all five decimals.

After the elimination of δC the group of equations determining the a in the first trial are

$$
\begin{aligned}
-3.514a_1 +0.02529a_2 \qquad\qquad\qquad\qquad\qquad + 138 &= 0\\
-0.002a_0 +0.10010a_1 +0.00038a_2 - 0.069a_3 + 171.0 &= 0\\
+0.056a_1 - 2.844\ a_2 - 0.108\ a_4 \qquad\qquad +1270 &= 0\\
-0.1268a_1 +0.003a_2 - 7.84a_3 - 214 &= 0\\
-0.003\ a_0 - 0.194a_2 - 14.84a_4 + 100 &= 0\\
-0.28\ a_3 - 23.84a_5 - 23 &= 0\\
-34.84a_6 - 44 &= 0
\end{aligned}
$$

. . . .

The final terms of these equations are in units of the tenth decimal. Their solution leads to the values

$a_0 = +128,\ a_1 = -1707,\ a_2 = +119,\ a_3 = 0,\ a_4 = +1$
$a_5 = -1,\ a_6 = -1,\ a_7 = 0,\ a_8 = -1,\ \delta C = +258.5$

The equations determining the a for the second trial differ only from those for the first trial in having different absolute terms, and their solution gives the values

$a_0 = +786.4,\ a_1 = -8.0,\ a_2 = +780.3,\ a_3 = +23.4$
$a_4 = +8.7,\ a_5 = +6.0,\ a_6 = -63.2,\ a_7 = -0.1$
$a_8 = +1.5,\ a_9 = +0.1,\ a_{10} = +0.2,\ \delta C = +1670.2$

When these corrections are applied severally to the coefficients of the approximate values of u employed in the two trials, the results are two values of u which differ only in their three first coefficients by 2 and 3 units in the tenth decimal, the following coinciding exactly. We give then only the result of the second trial, which, as it has been made with more care, is to be preferred.

$$
u = \left\{
\begin{array}{l}
-0.00188\,15565\\
+0.00057\,82691 \cos \phi\\
-0.01433\,26013 \cos 2\phi\\
-0.00002\,26099 \cos 3\phi\\
+0.00013\,20734 \cos 4\phi\\
+0.00000\,04283 \cos 5\phi\\
-0.00000\,13790 \cos 6\phi\\
-0.00000\,00070 \cos 7\phi\\
+0.00000\,00155 \cos 8\phi\\
+0.00000\,00001 \cos 9\phi\\
-0.00000\,00002 \cos 10\phi
\end{array}
\right\}
$$

The values of C from the two trials also agree well, they are $C = -0.00691\,749770$, $C = -0.00691\,749767$.

To derive from the just given expression the coordinates of the moon as functions of the time it is necessary to have the correct value of r. This is obtained by computing the correction δr to be added to the values of r in the second trial. We employ the equation

$$\delta r = F\delta C + G\delta u + H\frac{d.\delta u}{d\phi}$$

The principal results obtained are, in units of the tenth decimal.

ϕ	δu	$\frac{d\,\delta u}{d\phi}$	δr
°			
0	+1535.0	0	+829.3
15	1475.5	− 523	763.7
30	1220.5	1448	+481.4
45	752.8	1960	− 35.6
60	305.0	1301	530.8
75	99.8	− 308	762.5
90	80.0	+ 37	788.3
105	128.2	106	731.0
120	+ 350.0	+1367	−481.3
135	+ 805.1	+1916	+ 22.1
150	1246.5	1288	511.3
165	1454.5	+ 371	743.1
180	+1493.0	0	+786.1

When the corrections in the last column are applied to the mentioned set of values of r and the periodic development of this quantity derived, we get

$$
r = \left\{
\begin{array}{l}
+0.00061\,24345\,1 \cos \phi\\
-0.02042\,24560\,4 \cos 2\phi\\
-0.00003\,88175\,1 \cos 3\phi\\
+0.00024\,75192\,1 \cos 4\phi\\
+0.00000\,09433\,5 \cos 5\phi\\
-0.00000\,32169\,3 \cos 6\phi\\
-0.00000\,00186\,3 \cos 7\phi\\
+0.00000\,00433\,7 \cos 8\phi\\
+0.00000\,00002\,3 \cos 9\phi\\
-0.00000\,00006\,2 \cos 10\phi
\end{array}
\right\}
$$

The integration of this expression gives

$$
\tau = \phi + \left\{
\begin{array}{rl}
+ & 126''.32369 \sin \phi\\
- & 2106.21697 \sin 2\phi\\
- & 2.66890 \sin 3\phi\\
+ & 12.76362 \sin 4\phi\\
+ & 0.03892 \sin 5\phi\\
- & 0.11059 \sin 6\phi\\
- & 0.00055 \sin 7\phi\\
+ & 0.00112 \sin 8\phi\\
+ & 0.00001 \sin 9\phi\\
- & 0.00001 \sin 10\phi
\end{array}
\right\}
$$

From this formula are derived the following corresponding values of τ and ϕ:

τ	ϕ		
°	°	′	″
15	15	17	8.75640
30	30	29	29.55616
45	45	33	37.86824
60	60	28	27.66264
75	75	15	23.69115
90	89	57	53.58146
105	104	40	32.45790
120	119	27	54.62453
135	134	23	25.41221
150	149	28	26.23660
165	164	41	47.23948

From these special values we derive the periodic development of ϕ in terms of τ:

$$
\phi = \tau + \left\{
\begin{array}{rl}
- & 125''.68900 \sin \tau\\
+ & 2106.27704 \sin 2\tau\\
+ & 0.73711 \sin 3\tau\\
+ & 8.74182 \sin 4\tau\\
+ & 0.00763 \sin 5\tau\\
+ & 0.04902 \sin 6\tau\\
+ & 0.00006 \sin 7\tau\\
+ & 0.00032 \sin 8\tau
\end{array}
\right\}
$$

A comparison of this formula with the corresponding one employed at the outset shows that the coefficient of the parallactic inequality in the latter needs the correction $+0''.0375$.

Astronomers have been accustomed to employ the function $\frac{a}{r}$ of the moon's radius. In order to obtain this we substitute the just given special values of ϕ in the expression for $\frac{r^2}{a^2}$ in terms of ϕ; then, by extracting the square root and taking the reciprocal, we have the following special values:

τ	$\frac{a}{r}$
0	1.00785 52819
15	1.00687 82756
30	1.00422 86149
45	1.00065 67204
60	0.99714 55263
75	0.99463 05661
90	0.99376 63268
105	0.99478 25258
120	0.99743 74708
135	1.00106 63735
150	1.00472 62613
165°	1.00742 99059
180	1.00812 50531

Thence we have the following periodic development:

$$\frac{a}{r} = \left\{ \begin{array}{l} 1.00090\,73946 \\ -0.00028\,72775 \cos \tau \\ +0.00718\,65934 \cos 2\tau \\ +0.00000\,23529 \cos 3\tau \\ +0.00001\,58501 \cos 4\tau \\ +0.00000\,00385 \cos 5\tau \\ +0.00000\,03269 \cos 6\tau \\ +0.00000\,00004 \cos 7\tau \\ +0.00000\,00025 \cos 8\tau \end{array} \right\}$$

The coefficients of the expressions for ϕ and $\frac{a}{r}$ may be trusted as correctly corresponding to the assumed values of the three elements, m, $\frac{a}{a'}$, and γ, to within a very few units of the last decimal noted.

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1895 (*SWIFT, Aug. 20*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY E. E. BARNARD.

1895 Mt. Hamilton M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Aug. 21 11 23 44	1	12 , 4	−0 21.42	− 8 30.3	0 30 11.41	+5 38 54.9	*n*9.5315	0.692
22 11 16 41	1	12 , 4	+2 0.37	− 3 29.9	0 32 33.21	+5 43 55.5	*n*9.542	0.686
23 11 7 54	1	6 , 5	+4 19.23	+ 0 49.0	0 34 52.09	+5 48 14.5	*n*9.549	0.687
24 12 36 22	1	8 . 4	+6 44.80	+ 5 18.4	0 37 17.68	+5 52 14.1	*n*9.338	0.670
26 11 45 59	2	9	−0 23.02	. . .	0 41 38.18	. . .	*n*9.459	. .
12 2 24	2	3	. . .	−10 59.3	. . .	+5 59 28.6	. .	0.672
27 11 51 18	2	14 . 5	+1 46.04	− 8 5.2	0 43 47.27	+6 2 22.9	*n*9.459	0.675

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 30 29.58	+3.25 +3.29	+5 47 3.4	+21.8 +22.2	R. H. Tucker, meridian circle
2	0 41 57.90	+3.30 +3.33	+6 10 5.2	+22.7 +22.9	½(W. Bessel, O, 689 + Yarnall (F) 393)

The star no. 1 is DM. 5°76. This and 5°77 are, by a typographical error in the DM., given 2ᵐ too small in R.A.

This comet is large, some 6′ in diameter; very feebly brighter in the middle, and round. Though from its size it is visible in the 3¼-inch finder, it is faint and diffused in the 12-inch, and difficult to observe accurately.

It is in physical appearance a typical class I of the short-period comets, much resembling ENCKE's comet at its last return, and D'ARREST's comet in 1890. From its physical appearance I should say that it is a short-period comet.

Professor TUCKER very kindly observed the comparison-star with the Lick Observatory meridian circle; about three hours after the comet-measures. We have thus an excellent place for the star. He has supplied me with both the apparent and mean place of the star.

Aug. 27. Comet extremely faint; sky thick.

OBSERVATIONS OF COMET *a* 1895 (*SWIFT*),

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER AT GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY H. C. WILSON.

1895 Northfield M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Aug. 23 15 16 50	*a*	27 , 6	+0 0.66	−0 38.5	0 35 3.59	+5 48 49.0	8.974	0.741
25 14 29 19	*b*	12 . 6	+1 36.59	−3 45.8	0 39 30.85	+5 56 19.2	8.124	0.739
28 12 39 56	*d*	8 . 6	−1 31.65	−1 39.9	0 45 45.95	+6 4 27.2	*n*9.241	0.741

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
a	0 34 59.66	+3.27	+5 49 5.2	+22.3	Micrometer-comparison with *c*
b	0 37 50.96	+3.30	+5 59 42.5	+22.5	Micrometer-comparison with *c*
c	0 33 51.94	+3.27 +3.31	+6 0 24.1	+22.2 +22.5	Bonn VI, +5°88
d	0 47 14.26	+3.34	+6 5 43.9	+23.2	Schjellerup, 303

Star *a* was of the tenth magnitude, and was compared micrometrically with DM. 5°87: $\Delta\alpha = +1^m\,12^s.60$; $\Delta\delta = -11'\,9''.4$; with Bonn VI, 5°88: $\Delta\delta = +1^m\,7^s.72$; $\Delta\delta = -11'\,18''.8$; and with DM. 5°95: $\Delta\alpha = -2^m\,51^s.10$; $\Delta\delta = -10'\,37''.1$.

Star *b* is DM. 5°95, and was compared micrometrically with Bonn VI, 5°88: $\Delta\alpha = +3^m\,59^s.00$; $\Delta\delta = -41''.6$. The measures have been corrected for refraction.

OBSERVATIONS OF COMET *a* 1895 (*SWIFT*),

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

By LEWIS BOSS.

1895 Albany M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Aug. 24 12 58 22	1	6	−0 53.47	−7 47.9	0 37 0.66	+5 52 17.0	*n*9.202	0.725
25 13 17 11	1	10	+1 22.79	−4 2.8	0 39 16.91	+5 56 2.2	*n*9.088	0.723
31 15 51 17	2	7	−1 5.61	−7 37.3	0 51 50.13	+6 9 22.9	9.269	0.724
Sept. 3 13 20 40	3	11	−1 17.79	−1 47.0	0 57 5.62	+6 10 41.4	*n*8.921	0.719

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 37 50.85	+3.28 +3.30	+5 59 42.5	+22.4 +22.5	Yarnall 359
2	0 52 52.44	+3.40	+6 16 36.5	+23.7	Mayer 34
3	0 58 19.98	+3.43	+6 12 4.4	+24.2	Glasgow 259, Paris 1366, Gotha 16

Place of star 2 deduced with pr. m. $+0^s.002$, $-0''.02$ from many catalogues.

On September 3.7 the correction of the ephemeris (*A.J.* 352) was -24^s and $-3'.6$.

AUGUST METEORS,

By EDWIN F. SAWYER.

A watch of one hour's duration on Aug. 10, from $8^h\,45^m$ to $9^h\,45^m$ Boston M.T. (9, 11 and 12 overcast), revealed a remarkable paucity of meteors, only seven being noted, all apparently Perseids. Of the seven seen, only three were observed with sufficient accuracy to allow their paths being traced, as follows:

$9^h\,5^m$ 3 mag. from R.A. 25° +64° to 15° +66° ; $9^h\,10^m$ 4 mag. from R.A. 25° +65° to 13° +68°

$9^h\,18^m$ 1 mag. from R.A. 50° +54° to 55° +50°.

Moonlight troublesome after $9^h\,30^m$. Very clear. Center of observation in *Cassiopea*.

Brighton, 1895 *Aug.* 13.

NEW ASTEROID.

Prof. KREUTZ communicates the discovery of another small planet on Aug. 22, by CHARLOIS. Its position was observed *CB* 12½M Aug. 23 $9^h\,53^m.7$ Nice M.T. $\alpha = 22^h\,43^m\,1^s.3$. $\delta = -5°\,36'\,39''$. Daily motion, -44^s in α, and 2′ southward.

CORRIGENDUM.

No. 352, p. 132, col. 2, line −8, *for* June 24 *put* June 28.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, 5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office at Boston, Mass., as second-class matter. *Closed September 6.*

THE

ASTRONOMICAL JOURNAL.

No. 354.

VOL. XV. BOSTON, 1895 SEPTEMBER 13. NO. 18

A DETERMINATION OF THE POLAR DIAMETER OF *MARS*,

By W. W. CAMPBELL.

The determination of planetary diameters is not a simple problem. To obtain a micrometer-estimate of an apparent diameter, correct that estimate for differential refraction, reduce it to distance unity, and call the result the diameter at distance unity, is sometimes satisfactory, if special precautions have been taken; but in some cases it is not.

Diameter-measures are affected by a variety of errors, among which we may mention:

(*a*). *Spherical aberration.* Any defect in the telescope arising from imperfect correction for spherical aberration increases the apparent diameter of the object. This defect in good telescopes is small; but when it is desired to express diameter-results to thousandths, or even to hundredths, of a second of arc, I question whether the defect is negligible in any telescope. [In the focus of the Lick 36-inch equatorial, 0″.01 equals 0.00003 inch.] Whatever the magnitude of the defect, it may be regarded as constant throughout a series of diameter-measures.

(*b*). *Chromatic aberration.* If a refracting telescope is used, chromatic aberration increases the apparent diameter of an object quite appreciably. The increase varies somewhat with the color of the object; but throughout a series of measures of any given object it may be regarded as constant.

(*c*). *Imperfect atmospheric conditions.* Aside from the ordinary refractive effect of our atmosphere upon the apparent diameters of a planet, which can be eliminated satisfactorily, there is the irregular refraction caused by the unsteadiness of our atmosphere. Its effect—"poor seeing"—is always to increase the apparent size of the image. The increase is small in good seeing, and extremely large in poor seeing. Fortunate is the observer whose atmospheric conditions throughout a series of diameter-determinations are such as to increase the apparent diameter only a few hundredths of a second of arc.

(*d*). *Irradiation.* The apparent diameter of a planet observed upon a dark-sky background is very materially increased by irradiation. With any given telescope, eyepiece, planet and background, the increase of apparent diameter by irradiation may be regarded as sensibly constant.

(*e*). *Diffraction.* The diffraction-effect is small, and may be regarded as constant for any given object, telescope, and eyepiece. It always increases the apparent diameter of a planet.

(*f*). *Imperfect focus.* If the micrometer-threads are imperfectly placed for focus, the effect is always to increase the apparent diameter of an object. Evidently this effect is a variable one, but it is by no means always inappreciable. [In the 36-inch telescope, an error of 0.001 inch in focusing increases the diameter of a planet 0″.02.]

It should be noted that these six causes all unite to increase the apparent diameter of the object. None of them decrease it. No combination of lenses, and no combination of errors, will cause the image of a planet to be too small—ordinary refraction excepted. The apparent diameter is always too large.

Other errors that enter the problem are:

(*g*). *Personal equation.* The observer in setting micrometer-threads, in estimating contacts of images, etc., may systematically obtain results too large or too small. The personal habit may vary with time, with the object and its diameter, with the position of the wires in respect to the vertical, or otherwise. However, if the observations are made under circumstances quite similar, the effect of personal equation may be regarded as essentially constant.

(*h*). *Accidental errors.* All observations for determining diameters are subject to the usual unavoidable errors. If the number of observations is large, these errors readily submit to analysis.

At the 1892 opposition of *Mars* I made a series of diameter-measures of the planet with the 36-inch equatorial and filar micrometer, solely to obtain the data necessary for reducing my micrometer-observations of *Phobos* and *Deimos*. Though the measures were made with care, I was convinced of their absolute worthlessness so far as the secondary question of the diameter of the planet was concerned. A subsequent study of the general problem of determining planetary diameters convinced me that the diameter of *Mars* could be obtained satisfactorily with the 36-inch telescope and filar micrometer, that the magnitude of the errors mentioned above could be made very small, and that the systematic errors could be eliminated. Experiments were made in June and July 1894, to determine the best method of procedure during the opposition then approaching. The results of the experiments were in some respects extremely decisive, and the following programme was followed.

(*A*). All the observations were made with the sun above the horizon; just after sunrise before opposition, and before sunset after opposition. The advantages of the bright-sky background were very marked. Measures made with the utmost care at night on the dark-sky background were systematically 0″.3 to 0″.6 greater than those made after sunrise. Measures made between dawn and sunrise progressively decreased as the sky brightened. Those made in the first hour after sunrise showed no sensible variation. In no case were the measures, given below, made before the sun was well above the horizon. The use of the bright-sky background reduced the magnitude of the errors due to irradiation and chromatic aberration. In fact, I have no doubt it reduced the magnitude of all the errors, except possibly that of personal equation. The method applies especially well to *Mars*, since the well-known greater brightness of the limb of that planet leaves no doubt where background ends and sky begins. The edge of the planet was beautifully definite upon the bright sky. My measures were all made upon the diameter joining the cusps, and therefore night measures would have been influenced by the large and variable irradiation-effects of the south polar cap. The bright background reduced the influence of the cap to a minimum.

(*B*). No observations were made unless the atmosphere was very tranquil, giving sharply defined images. Observations in the month preceding and the month following opposition were not attempted, because the planet was too low in the sky when the sun was above the horizon. The thirty days on which observations were made represent all the favorable days, with the telescope at my command, between July 20, 1894, and June 1, 1895. It should be noted that the seeing here is, as a rule, much better during the hour after sunrise than during the hour before sunset.

(*C*). The same eyepiece, magnifying 520 diameters, was used throughout the series.

(*D*). After focusing the eyepiece and object-glass upon the threads, a cap was placed over the eyepiece, the cap having a 0.03-inch circular hole in its center. The use of the eyepiece cap is beneficial in some ways, and no doubt detrimental in others. Let us consider, first, its application in the case of a star. The cap reduces the size of the beam that enters the eye. The rays cut out are those from the outer portions of the object-glass, if the image is central in the eyepiece; those from the center of the object-glass passing through unmolested. The interposition of the cap no doubt produces a diffraction-effect, and the theoretical resolving power is thereby reduced; but in certain work on bright objects this loss of resolving power is more than made up by corresponding gains in other directions. Thus, the chromatic and spherical aberrations from the outer portions of the object-glass are eliminated. The effects of imperfect seeing are decreased by reducing the cross-section of the imperfect atmospheric lens through which the rays must pass. The focus is sharpened. The irradiation is decreased by reducing the contrast between bright object and darker sky.

The effect of the eyepiece cap, in the case of a planet of considerable size, differs from that of a star, in that the light from different portions of the object-glass is cut out for different portions of the planet; an effect that is open to objection.

In order to reduce the effect of chromatic aberration still further, I cut out the red and blue light by means of a glass screen. The screen consisted of a plane disc of orange-yellow glass, and a similar disc of green glass, placed in contact with the eye-lens of the eyepiece. The screen was tested in the eyepiece of a spectroscope, and found to transmit that part of the spectrum lying between wave-lengths 5100 and 6000. Observations made on the first eight mornings, both with the screen and without the screen, showed that the effect of the screen on the measures was inappreciable, and its use was discontinued. The use of the bright-sky background and of the eyepiece cap had evidently reduced the effect of chromatic aberration to a minimum.

(*E*). The observer's eyes were always similarly situated with respect to the threads.

(*F*). The threads were always placed parallel to the great circle passing through *Mars* and the *Sun*; so that the measures refer to the diameter joining the two cusps. Throughout the series of observations the cusps were from 23°.6 to 27°.6 from the poles of the planet. No measures were attempted in the direction at right angles to the line joining the cusps; the correction for phase would have been uncertain, on account of the unequal illumination of limb and terminator, and the variable illumination of the terminator.

In order to deduce the equatorial and polar diameters from the measures of the diameter joining the cusps, it was intended to observe the polar and equatorial diameters on four nights immediately preceding opposition, and on four nights in the week following, for the purpose of determining the polar compression. A carefully arranged programme was prepared, but storms and poor seeing prevented measures on every night. I thereupon concluded to use Professor

YOUNG's value of the polar compression, $\frac{1}{219}$. His value has the double merit of having been determined from a carefully planned series of observations, carefully reduced, and of coinciding very closely with the theoretical value subsequently announced by Professor ADAMS.

(*G*). The micrometer threads were placed directly upon the opposite limbs of the planet. Before a setting was accepted, the screw which moves both threads simultaneously was turned so that these were shifted, first to one side of the limbs and then to the other side, so that in both cases both limbs were just uncovered. When the uncovered portions were estimated to be equal, the setting was accepted. This method worked well in observations made after sunrise, but poorly in night observations. The individual settings were remarkably accordant. Whatever systematic errors attached to the method were small, and were assignable to personal equation.

The observations were made by the method of "double distance." Each observation recorded below consisted of ten thread-settings, or five double diameters; and 106 observations, consisting of 1060 settings, were secured on thirty days. The value of a revolution of the micrometer-screw was used as 9″.907.

The times of observation are given in the first column of the table below. The numbers in the second column indicate both the number of observations and their weight. The third column contains the measured values of the cusp diameters, corrected for refraction; and the value of the refraction-correction used is given in column four. The distances, q, of the cusps from the poles of the planet are contained in column five. Log f is the logarithm of the factor f which reduces the cusp-diameters to the corresponding polar diameters, on the assumption that the polar compression is $\frac{1}{219}$. The polar diameters thus obtained are given in column seven. Log r is the logarithm of the distance between *Mars* and the *Earth*.

The results for the measures and reductions are carried out to thousandths of a second; not that the third decimal is believed to be significant, but to prevent accumulated errors from seriously affecting the second place. A hundredth of a second at distance unity is about four and one-half miles; a thousandth is less than half a mile, and I think the third decimal in the final result can be dropped without serious sacrifice.

Pacific Standard Time of Observation	No. of Observns.	Cusp Diameter	Corr. for Refraction	q	log f	Polar Diameter	log r
d h m		″	″	°		″	
1894 July 20 19 0	1	12.386	+0.004	23.6	9.99936	12.368	9.87578
27 18 12	4	13.054	4	23.8	35	13.034	9.85296
28 18 31	4	13.188	4	23.7	35	13.168	9.84959
Aug. 3 17 58	4	13.821	4	23.9	35	13.800	9.82941
4 18 21	4	13.929	4	24.0	34	13.908	9.82593
7 18 30	4	14.265	4	24.2	33	14.243	9.81559
8 18 20	4	14.370	4	24.3	32	14.348	9.81215
11 17 52	4	14.703	4	24.3	32	14.680	9.80177
14 18 8	2	15.018	4	24.4	32	14.995	9.79120
15 18 26	2	15.158	4	24.5	31	15.134	9.78763
22 18 0	2	16.077	5	24.9	29	16.051	9.76282
29 18 20	10	17.053	5	25.3	27	17.024	9.73782
Sept. 4 18 10	2	17.791	5	25.7	25	17.760	9.71683
5 18 7	2	17.969	5	25.8	24	17.938	9.71340
7 18 38	6	18.239	6	26.0	23	18.207	9.70654
8 18 25	7	18.403	6	26.1	22	18.370	9.70322
14 18 29	2	19.300	6	26.7	19	19.264	9.68393
19 18 13	1	19.915	7	27.2	16	19.876	9.66933
20 18 32	4	19.993	8	27.4	15	19.954	9.66656
22 18 15	3	20.245	8	27.6	13	20.205	9.66137
1895 Jan. 10 5 5	3	9.727	3	27.5	14	9.708	9.98102
Feb. 1 4 17	2	7.980	2	27.3	15	7.964	0.07033
26 5 12	2	6.671	3	26.8	18	6.658	0.15324
27 5 5	5	6.561	2	26.9	17	6.549	0.15622
Mar. 9 5 18	6	6.010	2	26.7	19	5.999	0.18493
Apr. 6 5 27	3	5.110	1	25.8	24	5.101	0.25404
10 6 4	5	5.148	1	25.5	26	5.139	0.26271
12 6 8	3	5.112	1	25.6	25	5.103	0.26692
19 5 55	3	4.888	1	24.4	32	4.880	0.28106
May 7 5 58	2	4.449	+0.001	24.9	9.99929	4.442	0.31368

In reducing these observations let

r = the distance of *Mars* from the observer;

D = the most probable value of the polar diameter of *Mars* at distance unity;

d = the measured value of the polar diameter;

i = the constant error of the measured diameters, due to chromatic aberration, spherical aberration, irradiation, diffraction, personal equation.*

Then each observation furnishes an equation of the form

$$d = \frac{D}{r} + i \tag{1}$$

in which D and i are unknown quantities. Let us assume, for convenience in the solution, that an approximate value of D is 9″.20, and that x is an unknown small correction to 9″.20, such that

$$D = 9''.20 + x \tag{2}$$

Substituting this value of D in equation (1), we obtain

$$i + \frac{1}{r}x - \left(d - \frac{9''.20}{r}\right) = 0; \tag{3}$$

which is the form of observation equation to be employed, i and x being the unknown quantities.

If we substitute the successive values of r and d in equation (3), we obtain thirty equations of condition, as below. (4)

Equations of condition (logarithmic coefficients)				Final residuals
0.00000 i	+0.12422 x	+n9.08636	= 0	v = +0.004
0.00000	+0.14704	+n9.10380	= 0	+0.003
0.00000	+0.15041	+n9.20412	= 0	−0.029
0.00000	+0.17059	+n9.24055	= 0	−0.040
0.00000	+0.17407	+n9.23553	= 0	−0.037
0.00000	+0.18441	+n9.24551	= 0	−0.039
0.00000	+0.18785	+n9.22789	= 0	−0.031
0.00000	+0.19823	+n9.19866	= 0	−0.018
0.00000	+0.20880	+n9.06070	= 0	+0.027
0.00000	+0.21237	+n9.12057	= 0	+0.010
0.00000	+0.23718	+n9.22272	= 0	−0.019
0.00000	+0.26218	+n9.29667	= 0	−0.045
0.00000	+0.28317	+n9.00432	= 0	+0.057
0.00000	+0.28660	+n9.14301	= 0	+0.020
0.00000	+0.29346	+n9.09691	= 0	+0.036
0.00000	+0.29678	+n9.17319	= 0	+0.012
0.00000	+0.31607	+n9.33214	= 0	−0.049
0.00000	+0.33067	+n9.24551	= 0	−0.006
0.00000	+0.33314	+n8.69897	= 0	+0.121
0.00000	+0.33863	+n9.14922	= 0	+0.031
0.00000	+0.01598	+n9.21219	= 0	−0.063
0.00000	+9.92967	+n9.14391	= 0	−0.039
0.00000	+9.84676	+n9.28556	= 0	−0.101
0.00000	+9.84378	+n9.11059	= 0	−0.037
0.00000	+9.81507	+ 8.04139	= 0	+0.100
0.00000	+9.74596	+ 8.39794	= 0	+0.109
0.00000	+9.73729	+n9.06070	= 0	−0.031
0.00000	+9.73308	+n9.10380	= 0	−0.044
0.00000	+9.71894	+n8.80618	= 0	+0.018
0.00000	+9.68632	+ 8.41497	= 0	v = +0.106

Multiplying these equations of condition through by the square roots of their respective weights, and forming the normal equations in the usual manner, we obtain

$$106.0000\,i + 118.3312\,x - 13.7290 = 0$$
$$148.3312\,i + 240.8558\,x - 21.0157 = 0$$

The solution of these equations gives

$\log i = 8.72984$ $\log x = 8.73395$

$i = +0''.054 \pm 0''.018$ $x = +0''.054 \pm 0''.012$

These values of the unknown quantities i and x when substituted in the equations of condition furnish the residuals v printed opposite the equations (4).

The resulting value of i signifies that the diameters were systematically observed too great by the amount

$$\mathbf{i = +0''.054 \pm 0''.018}$$

The resulting value of x signifies that the most probable value of the polar diameter of *Mars* at distance unity is $D = 9''.200 + x = 9''.251 \pm 0''.012$; or, to preserve only two places of decimals

$$\mathbf{D = 9''.25 \pm 0''.012}$$

If we adopt Professor Young's value of the polar compression, $\frac{1}{215}$, the equatorial diameter resulting from my measures is 9″.30.

In this connection, I take pleasure in saying that the observations made before opposition, *i.e.*, between July 20 and September 22, were reduced for me by each and all of the students forming a large class in the method of least squares in the University of California, of which institution the Lick Observatory is a department. The reductions were made under the immediate direction of the instructor, Assistant Professor A. O. Leuschner, and their discussion of the observations was complete in every particular. Their results for the cusp diameter were

$$D = 9''.220 \pm 0''.018$$
$$i = +0''.153 \pm 0''.029$$

In the observations used by them the measured diameters ranged only from 12″.4 to 20″.2, and necessarily the value of i was not so determinate as when the full series of observations was employed and the diameter varied from 4″.4 to 20″.2. I have made use of their reduction-constants in my final reduction of all the observations, in so far as the constants naturally coincide.

I shall here include, for the convenience of the reader, a list of the values of D and i previously determined from extensive series of observations. The values are taken, for the most part, from Dr. Hartwig's classical paper* on the diameters of *Venus* and *Mars*. The results credited to Bessel are those obtained from Bessel's observations by Prof. Oudemans, and they refer, not to a polar diameter, but to a mean diameter. The polar diameter would apparently be somewhat smaller than the mean diameter. Prof.

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* The errors due to imperfect atmospheric conditions and to improper focus are variable, and therefore do not unite wholly with the constant errors in forming i: and since they are always positive, they do not unite wholly with the accidental errors. They unite in part with the constant errors, and in part with the accidental errors.

* *Publication der Astronomischen Gesellschaft*, XV, Leipzig, 1879.

Oudemans appears to have been the first to eliminate the systematic error i by using an equation essentially of the same form as (1), though Arago made a few investigations upon the magnitude of some of the systematic errors.

Observer	Date	Method	Polar diameter	i
			$''$ $''$	$''$ $''$
Arago	1813	Rochon's micrometer	9.167 ± 0.049	+ 0.157 ± 0.094
Bessel	1830–37	Heliometer	9.342 ± 0.019	− 0.053 ± 0.070
Kaiser	1862–65	Airy's micrometer	9.375 ± 0.013	+ 0.063 ± 0.021
Main	1862–63	Heliometer	9.404 ± 0.035	− 0.544 ± 0.070
Hartwig	1877–78	Heliometer	9.300 ± 0.022	− 0.107 ± 0.050
Campbell	1894–95	Filar micrometer	9.254 ± 0.012	+ 0.054 ± 0.018

The probable error of my result for the polar diameter is small; but far more gratifying is the small value of the systematic error i, and the determinateness of i indicated by its relatively small probable error.

Between October 25 and November 22, 1894, I observed the elongation-distances of the satellites of *Mars* on eleven nights. Since the elongation-distances were measured first from the limb and then from the terminator, in quick succession and with many repetitions, the differences of the measures from limb and terminator, when corrected for phase, were essentially the apparent equatorial diameter of the planet. Diameters obtained in that manner on the eleven nights were greater than Hartwig's values, contained in Marth's ephemeris, by the following amounts [see this Journal, no. 337]:

0.54″	0.49″	0.56″
0.61	0.42	0.63
0.45	0.54	0.60
0.40	0.56	

Mean = 0″.53

If we leave systematic errors out of consideration, these measures give an equatorial diameter of 9″.63 at distance unity, a result in good accord with filar-micrometer determinations by many other observers. The measures were made at night, using no eyepiece-cap.

I was continually indebted in the observations and reductions to Mr. Marth's ephemeris.

Mt. Hamilton, 1895 *July* 18.

PERIOD OF 3416 *S VELORUM.*

By ALEX. WM. ROBERTS.

A comparison of three sets of measures of *S Velorum*, made during May and July 1895, with those made on May 25 and July 23, 1894 (*Astr. Journal*, no. 327, p. 115), gives a period of 5d 22h 24m 21s ± 2s for this variable.

The method adopted, indeed the only one available, is to compare the ascending or descending curves.

Thus the measures taken on May 10 and May 16, 1895, during the ascending phase, were compared with the measures taken on May 25, 1894; and the measures taken July 14, 1895, during the descending phase with those of July 23, 1894. The resulting period is that given above.

The measures of July 23, 1894, are to some extent influenced by the variation of Cord. Z.C., IX, 2301 (*Astr. Journal*, no. 352, p. 134), this star being then apparently not far from a maximum. If we leave it out of account in reducing the magnitudes of *S Velorum* to a common standard, the first seven measures of July 23 will require to be diminished by 0M.04.

The detailed observations of May 10, May 16 and July 14, are as follows:

1895 May 10		1895 May 16		1895 July 14	
Gr. M.T.		Gr. M.T.		Gr. M.T.	
h m	M	h m	M	h m	M
6 2	9.20	5 19	9.10	4 59.5	8.25
6 32	9.40	5 32	9.00	5 4.5	8.35
6 44	9.30	5 36	8.95	5 12.5	8.30
6 57	9.20	5 43	8.95	5 23.5	8.40
7 19	9.20	5 51	8.90	5 28.5	8.45
7 27	9.10	5 57	8.90	5 33.3	8.40
7 43	8.80	6 9	8.80	5 42	8.48
7 53	8.75	6 13	8.80	5 48	8.53
8 5	8.60	6 19	8.70	5 54	8.55
8 12	8.60	6 24	8.70	5 58	8.60
8 19.5	8.63	6 33	8.60	6 1	8.62
8 28	8.55	6 40	8.62	6 3	8.60
8 38.5	8.55	6 46	8.50	6 13.8	8.75
8 58.5	8.33	7 3	8.45	6 17.8	8.70
9 6	8.32	7 17	8.35	6 26.7	8.85
9 31	8.20	7 32	8.25	6 31.7	8.85
9 47	8.10	7 55	8.15	6 37.7	8.90
10 6	8.03	8 45	8.00	6 43.5	9.05
10 22	8.00	9 6	7.95	6 50.5	9.10
10 37	8.00	9 24	7.95	6 54.5	9.30
		9 40	7.80	7 3.5	9.30

Each measure is, as usual, the mean of two observations, one direct, the other reverse. The method of reduction is explained in *Astr. Journal*, no. 327, p. 115, and the comparison-stars are those given on page 115 of the same number. Cord. Z.C., IX. 2301 is, however, not included. The measures of *S Velorum* taken during 1895 would seem to indicate that the ascending period is a few minutes longer than the descending period.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY JOHN H. OGBURN.

1895 Albany M.T.	✳	No. comp.	Planet − ✳ $\Delta\alpha$	Planet − ✳ $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			Henrietta (225).					
May 13 11h 34m 36s	1	9 . 5	−1m 3s.01	−1′ 3″.2	15h 39m 39s.25	− 1° 29′ 50″.0	*n*8.860	0.786
22 10 26 14	2	6 . 5	+2 5.73	+0 20.9	15 33 18.77	− 0 12 10.9	*n*9.080	0.777
23 9 23 0	2	6 . 1	+1 25.59	+7 19.8	15 32 38.63	− 0 5 11.9	*n*9.349	0.777
			Ophelia (171).					
May 29 10 56 8	3	7 . 4	+0 41.00	−3 47.1	16 29 25.07	−19 17 14.4	*n*9.101	0.889

Mean Places for 1895.0 of Comparison-Stars.

✳	α	Red. to app. place	δ	Red. to app. place	Authority
1	15h 40m 39s.70	+2s.59	− 1° 28′ 30″.0	−16″.8	Pulkowa,'55, Karls., Stone
2	15 31 10.39	+2.65	− 0 12 15.8	−16.0	Pulkowa,'55, Brus., Karls., Stone
3	16 28 38.08	+2.99	−19 43 13.3	−14.0	Argelander, Cincinnati Zone

ON THE CORRECTION OF PHOTOGRAPHIC MEASURES FOR REFRACTION.

BY F. W. DYSON.

In no. 350 of the *Astronomical Journal* in which Mr. JACOBY modifies Dr. RAMBAUT's formulas for calculating the refraction on photographic plates, he obtains results which appear to disagree with those given by Professor TURNER in the *Monthly Notices* of the Royal Astronomical Society for November, 1893. Mr. JACOBY considers that Prof. TURNER's results are incorrect, but seems to me not to have appreciated that in one case the corrections are to *the rectilinear coordinates measured on a photographic plate*, and in the other to *right-ascension and declination*. When this is borne in mind the results are perfectly accordant.

Adopting Prof. TURNER's notation, in which

α = Star's R.A.

A = R.A. of center of plate

p = Star's N.P.D.

P = N.P.D. of center of plate.

ξ, η = "Standard coordinates" of a star.

X, Y = Coordinates of the zenith as projected on the photographic plate.

The equations giving the "standard coordinates" in terms of right-ascension and declination are

$$(1)\left\{\begin{aligned}\eta &= \tan(P-q)\\ \xi &= \frac{\tan(\alpha-A)\sin q}{\cos(P-q)}\\ \text{where}\quad \tan q &= \tan p\cos(\alpha-A)\end{aligned}\right.$$

Solving these equations to find $\alpha-A$ and p explicitly in terms of ξ, η, we find

$$\left.\begin{aligned}\tan(\alpha-A) &= \frac{\xi\,\mathrm{cosec}\,P}{1-\eta\cot P}\\ \text{and}\quad p &= P-\eta+\tfrac{1}{2}\xi^2\cot P+\frac{\eta^3}{3}+\tfrac{1}{2}\xi^2\eta\,\mathrm{cosec}^2P+\&c.\end{aligned}\right\}\quad(2)$$

Prof. TURNER finds for the refractions

$$\left.\begin{aligned}\Delta\xi &= \beta'_0\{X-\xi(1+X^2)-\eta XY\}\\ \Delta\eta &= \beta'_0\{Y-\xi XY-\eta(1+Y^2)\}\end{aligned}\right\}\quad(3)$$

formulas which he obtained in a very simple manner by making use of the fact that a great circle on a sphere is projected into a straight line on a photographic plate, and that the distance from the zenith to the star is expressible as a function of X, Y, the coordinates of the projection of the zenith on the plate, and of ξ, η the coordinates of the star.*

Differentiating the formulas (2) we find

$$\left.\begin{aligned}\sec^2(\alpha-A)\,\Delta\alpha &= \frac{\Delta\xi\,\mathrm{cosec}\,P}{1-\eta\cot P}+\Delta\eta\,\frac{\xi\,\mathrm{cosec}\,P\cot P}{(1-\eta\cot P)^2}\\ \text{and}\qquad \Delta p &= -\Delta\eta+\xi\cot P\,\Delta\xi+\&c.\end{aligned}\right\}$$

---

* In Prof. TURNER's deduction of these formulas a misprint seems to have crept in. The expression on p. 19, line 5, should be multiplied by $\frac{1}{\sqrt{X^2+Y^2}}$. The next line is quite correct.

Substituting from (3) in these, and retaining only first powers of ξ and η

$$\left.\begin{aligned}\sin P\,\Delta\alpha &= -\beta_0\xi\{(1+X^2)-Y\cot P\}-\beta_0\eta\{XY-X\cot P\}\\ -\Delta p &= -\beta_0\xi\{XY+X\cot P\}-\beta_0\eta\{1+Y^2\}\end{aligned}\right\}$$

These are Mr. JACOBY's formulas, but the simpler ones of Prof. TURNER are better, for as Mr. JACOBY says, in which he agrees with Prof. TURNER, corrections are wanted which can be applied along with the corrections for orientation and scale-value to the measured rectangular coordinates. The rest of Mr. JACOBY's paper may be easily adapted to these formulas.

Perhaps some misunderstandings will be avoided by remembering that parallel lines on a photographic plate are the projections of circles which all pass through a point 90° distant from the center of the plate, while meridians and parallels of declination are projected into lines converging to a point and concentric circles.

Blackheath, 1895 *August* 26.

EPHEMERIS OF VARIABLES OF THE *ALGOL*-TYPE.

1895 Greenwich Mean Time.

BY PAUL S. YENDELL.

		h
October		
1	*U* Coronae	7
	δ Librae	11
	U Ophiuchi	12
2	*U* Ophiuchi	9
	U Cephei	9
	Z Herculis	14
3	λ Tauri	11
4	*Z* Herculis	13
	Y Cygni	16
	U Cephei	20
5	*S* Cancri	21
6	*U* Ophiuchi	13
	Z Herculis	14
7	*U* Cephei	8
	U Ophiuchi	9
	λ Tauri	10
	Y Cygni	16
	R Can. Maj.	16
8	*Z* Herculis	13
	R Can. Maj.	19
9	*U* Cephei	20
10	*Z* Herculis	14
	Y Cygni	16
October		
11	λ Tauri	9
	U Ophiuchi	14
	Algol	20
12	*U* Cephei	8
	U Ophiuchi	10
	Z Herculis	13
13	*Y* Cygni	16
14	*Z* Herculis	14
	Algol	17
	U Cephei	20
15	λ Tauri	8
	R Can. Maj.	15
16	*Z* Herculis	13
	U Ophiuchi	15
	Y Cygni	16
	R Can. Maj.	18
17	*U* Cephei	7
	U Ophiuchi	11
	Algol	14
18	*U* Coronae	13
	Z Herculis	14
19	*Y* Cygni	16
	U Cephei	19
October		
20	*Z* Herculis	12
	Algol	11
22	*U* Cephei	7
	Z Herculis	13
	Y Cygni	16
23	Algol	8
	R Can. Maj.	14
24	*Z* Herculis	12
	R Can. Maj.	17
	U Cephei	19
	S Cancri	20
25	*U* Coronae	11
	Y Cygni	16
	R Can. Maj.	21
26	*Z* Herculis	13
27	*U* Cephei	7
28	*Z* Herculis	12
	Y Cygni	15
29	*U* Cephei	19
30	*Z* Herculis	13
31	*R* Can. Maj.	13
	Y Cygni	15
November		
1	*U* Cephei	6
	R Can. Maj.	16
2	*R* Can. Maj.	20
3	*Z* Herculis	13
	Y Cygni	15
	U Cephei	18
	Algol	19
6	*U* Cephei	6
	Y Cygni	15
	Algol	16
7	*Z* Herculis	13
8	*R* Can. Maj.	12
	U Cephei	18
9	Algol	13
	Y Cygni	15
	R Can. Maj.	16
10	*R* Can. Maj.	19
11	*U* Cephei	6
	Z Herculis	13
12	Algol	9
	Y Cygni	15
	S Cancri	19
13	*U* Cephei	18
November		
15	*Z* Herculis	12
	Y Cygni	15
17	*R* Can. Maj.	15
18	*Y* Cygni	15
	U Cephei	17
	R Can. Maj.	18
19	*Z* Herculis	12
	R Can. Maj.	20
	λ Tauri	21
21	*Y* Cygni	15
23	*U* Cephei	17
	λ Tauri	20
	Algol	21
24	*Y* Cygni	15
25	*R* Can. Maj.	13
26	*R* Can. Maj.	16
	Algol	17
27	*Y* Cygni	15
	λ Tauri	19
	R Can. Maj.	19
28	*U* Cephei	17
29	Algol	11
30	*Y* Cygni	11

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1895 (*SWIFT*),

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY,

BY ORMOND STONE.

1895 Charlottesville M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s		m s	′ ″	h m s	° ′ ″		
Aug. 23 14 17 16	1	2	. . .	+1 0.9	. . .	+5 48 27.3	. .	0.669
15 9 41	1	5	+4 23.77	. . .	0 34 56.72	. . .	8.950	. .
25 15 44 15	2	6	+1 37.27	. . .	0 39 31.64	. . .	9.213	. .
16 10 56	2	2	. . .	−3 38.1	. . .	+5 56 26.1	. .	0.674
27 13 57 26	3	2	. . .	−3 55.8	. . .	+6 2 11.1	. .	0.672
15 13 41	3	5	−3 28.89	. . .	0 43 48.69	. . .	9.014	. .

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 30 29.67	+3.28	+5 47 4.2	+22.2	Mr. Littell, U.S.N. Observatory
2	0 37 51.07	+3.30	+5 59 42.0	+22.5	Dr. Kam, *Astron. Nachr.*, no. 1464
3	0 47 14.26	+3.32	+6 5 43.9	+23.0	Schjellerup 303

August 23. The nucleus was a fine stellar point of the 15th magnitude. It was not so stellar the other nights.

OBSERVATION OF COMET *a* 1895 (SWIFT),

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER AT GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY H. C. WILSON.

1895 Northfield M.T.	✳	No. Comp.	☄ — ✳		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
Aug. 30 14h 8m 56s	*e*	12 , 8	−0m 2s.35	−9′ 19″.1	0h 49m 53s.80	+6° 8′ 10″.0	*n*7.855	0.737

Mean Place for 1895.0 of Comparison-Star.

✳	α	Red. to app. place	δ	Red. to app. place	Authority
e	0h 49m 52s.77	+3s.38	+6° 17′ 5″.5	+23″.6	Yarnall 483

ELLIPTIC ELEMENTS AND EPHEMERIS OF COMET *a* 1895.

BY LEWIS BOSS.

Having failed to obtain a satisfactory representation of observations of this comet at the dates, Aug. 23.5, Aug. 28.8 and Sept. 3.8, by means of a parabola, I have computed the following elliptic elements, which show that this comet belongs to the family of *Jupiter.*

Epoch 1895 August 23.5 G.M.T.

$$M = 0\ \ 22'\ \ 39''.0$$

$$\left.\begin{array}{rcl}\omega &=& 167\ \ 10\ \ 51\\ \Omega &=& 170\ \ 34\ \ 35\\ i &=& 3\ \ \ 5\ \ 51\end{array}\right\}\ 1895.0$$

$$\varphi = 43\ \ 56\ \ 21$$

$$\mu = 401''.191$$

The perihelion was Aug. 20.1; and the period is 8.8 years. This latter is, of course, very uncertain, though the observations thus far are well represented. It seems superfluous to call the attention of observers to the importance of securing many observations of this comet.

EPHEMERIS FOR GREENWICH MIDNIGHT.

1895	App. α	App. δ	log Δ
	h m s	° ′	
Sept. 12.5	1 9 58	+5 58.2	9.5665
14.5	1 12 18	5 52.3	9.5696
16.5	1 14 23	5 45.5	9.5743
18.5	1 16 15	5 37.9	9.5789
20.5	1 17 55	5 29.7	9.5841
22.5	1 19 23	5 21.1	9.5897
24.5	1 20 40	5 12.1	9.5959
26.5	1 21 48	5 3.0	9.6026
28.5	1 22 45	4 53.8	9.6097
30.5	1 23 35	4 44.7	9.6173
Oct. 2.5	1 24 16	4 35.6	9.6253
4.5	1 24 52	4 26.8	9.6338
6.5	1 25 20	4 18.5	9.6427

On October 4, the theoretical brightness is 0.6, that at discovery being the unit.

NEW ASTRONOMICAL WORK.

W. SCHUR. *Die Oerter der helleren Sterne der Praesepe.* Göttingen, 1895. 314 pp.

This elaborate work, which forms the Fourth Part of the "*Astronomische Mittheilungen*" of the Göttingen Observatory, contains the relative positions resulting from Prof. SCHUR's triangulation of the *Praesepe* with the Repsold six-inch heliometer, received in 1888.

The first section contains a full description of the instrument, with an investigation of its contents, together with the details and final results of the triangulation, executed during the years 1889 to 1893.

The second gives the results of the similar investigation made with the Bonn heliometer by WINNECKE in 1857 and 1858, just before the commencement of his activity at Pulkowa. The almost completed results were in WINNECKE's hands for final revision, when the state of his health prevented his continuance of the work. After the delays, first of twenty years, while WINNECKE was actively engaged in other researches at Pulkowa, and then of more than ten years after he had taken the manuscript again in hand, at Strassburg, the final revision and partly new reduction were undertaken by Prof. SCHUR.

In the third section are comparisons of the results of these series of heliometer-observations, with each other, and with HALL's larger catalogue, determined at Washington with the filar micrometer; as also with the positions for the same stars, deduced since then from RUTHERFURD's photographs of 1867.

CORRIGENDA.

No. 353, p. 138, col. 2, l. 2, *for* motions *put* motion : p. 138, col. 2, l. 28, substitute $d\tau$ for dt in denominator of second term.

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CORRIGENDA.

PUBLISHED IN BOSTON, SEMI-MONTHLY BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office at Boston, Mass., as second-class matter. *Closed September 13.*

THE

ASTRONOMICAL JOURNAL.

No. 355.

VOL. XV. BOSTON, 1895 OCTOBER 2. NO. 19

OBSERVATIONS OF VARIABLE STARS OF THE *ALGOL*-TYPE, 1893–1895,

By PAUL S. YENDELL.

The following observations are the results of my work on stars of this class during the interval between 1893 September 2 and 1895 May 1.

320 *U Cephei.*

Three minima, and one normal minimum made up from four different nights' observations.

1894 November 19; eighteen observations, from 9h 4m to 16h 40m.

Time of minimum by single curve, 14h 0m, wt. 4.

Time of minimum by mean curve, 14h 16m.2.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
8.4	11 53	16 29	14 11.0
8.6	12 18	15 48	14 3.0
8.8	12 37	15 26	14 1.5
9.0	13 0	15 0	14 0.0
		Mean	14 3.9

Least observed light, 9M.05.

1894 December 4; eighteen observations, from 10h 40m to 15h 35m.

Time of minimum by single curve, 12h 56m, wt. 1.

Time of minimum by mean curve, 12h 58m.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
8.6	11 22	14 33	12 57.5
8.8	11 39	14 14	12 51.5
		Mean	12 54.5

Least observed light, 9M.09.

1895 January 23; fifteen observations, from 7h 24m to 11h 58m.

Time of minimum by single curve, 9h 41m, wt. 5.

Time of minimum by mean curve, 9h 33m.4.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
8.6	7 44	11 35	9 40
8.8	8 13	10 55	9 34
9.0	8 26	10 41	9 33
		Mean	9 35.7

Least observed light, 9M.09.

Normal minimum, from observations as follows:

1894 Oct. 25	decrease	12	observations
Dec. 19	"	9	"
29	"	7	"
1895 Feb. 22	"	5	"
23	increase	6	"
		39	

Referred to Epoch 2123, these observations give a minimum by the use of the mean light-curve.

1894 December 19 12h 30m.24

1090 *Algol.*

Four minima:

1894 September 22; nine observations, from 9h 23m to 11h 45m.

Time of minimum by single curve, 10h 42m, wt. 1.

Time of minimum by mean curve, 10h 31m.4.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
3.4	10 2	11 30	10 46
3.6	10 24	11 4	10 44
		Mean	10 45

Least observed light, 3M.7.

1894 November 7; nine observations, from 5h 57m to 9h 21m.

Time of minimum by single curve, 8h 1m; rather uncertain.

Time of minimum by mean curve, 7h 55m.1.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
3.5	7 25	8 34	7 59.5
3.6	7 36	8 23	7 59.5
		Mean	7 59.5

Least observed light, 3M.7.

1894 November 27; sixteen observations, from 6h 15m to 11h 33m.

Time of minimum by single light-curve, 9h 23m, wt. 5.

Time of minimum by mean light-curve, 9h 32m.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
3.6	9 17	9 40	9 28.5
3.4	8 31	10 46	9 38.5
3.2	8 16	11 20	9 48.0
		Mean	9 38.3

Least observed light, $3^{M}.7$.

1894 December 20; twelve observations, from 5^{h} 40^{m} to 12^{h} 33^{m}.

Time of minimum by single curve, 7^{h} 55^{m}, wt. 5.

Time of minimum by mean curve, 7^{h} $49^{m}.9$.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
2.8	6 13	10 33	8 23
3.0	6 22	10 7	8 14.5
3.2	6 30	9 42	8 6
3.4	6 38	9 4	7 51
3.6	7 30	8 5	7 47.5
		Mean	8 4.4

Least observed light, $3^{M}.7$.

1411 *λ Tauri.*

Four minima:

1893 November 18; ten observations, from 8^{h} 15^{m} to 11^{h} 43^{m}.

Time of minimum by single curve, 10^{h} $41^{m}.5$, wt. 4.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
4.2	10 28	11 3	10 45.5

Least observed light, $4^{M}.3$. Bright moonlight.

1893 November 22, ten observations, from 6^{h} 57^{m} to 11^{h} 22^{m}.

Time of minimum by single curve, 9^{h} 31^{m}, wt. 3.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
4.0	7 8	11 2	9 5
4.1	7 48	10 32	9 10
4.2	8 12	10 18	9 15
4.3	8 40	10 12	9 26
		Mean	9 14

Least observed light, $4^{M}.4$. Full moon.

1893 November 26; nine observations, from 6^{h} 25^{m} to 10^{h} 50^{m}.

Time of minimum by single curve, 9^{h} 30^{m}, wt. 2; uncertain.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
4.0	7 42	10 50	9 16
4.1	8 33	10 23	9 28
		Mean	9 22

Least observed light, $4^{M}.2$.

1893 November 30; seven observations, from 6^{h} 0^{m} to 10^{h} 10^{m}.

Time of minimum by single curve, 9^{h} 16^{m}, wt. 3.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
3.8	7 14	10 8	8 41
4.0	8 0	10 2	9 1
4.2	8 58	9 46	9 22
		Mean	9 1.3

Least observed light, $4^{M}.25$.

2610 *R Canis Majoris.*

Four minima, and one normal minimum, formed from observations on three separate dates.

1895 January 29; thirteen observations, from 7^{h} 25^{m} to 11^{h} 50^{m}.

Time of minimum by single curve, 11^{h} 7^{m}, wt. 4.

Time of minimum by mean curve, 11^{h} $13^{m}.7$.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
6.4	10 15	11 26	10 50.5
6.6	11 3	11 19	11 11
		Mean	11 0.8

Least observed light, $6^{M}.25$.

1895 February 14; ten observations, from 7^{h} 13^{m} to 9^{h} 15^{m}.

Time of minimum by single curve, 8^{h} 48^{m}, wt. 4.

Time of minimum by mean curve, 8^{h} $44^{m}.7$.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
6.3	7 33	9 48	8 40.5
6.5	7 53	9 32	8 42.5
6.7	8 14	9 27	8 50.5
		Mean	8 44.5

Least observed light, $6^{M}.8$.

1895 February 23; nineteen observations, from 7^{h} 0^{m} to 11^{h} 45^{m}.

Time of minimum by single curve, 10^{h} 20^{m}, wt. 5.

Time of minimum by mean curve, 10^{h} $21^{m}.4$.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
6.5	9 15	11 36	10 25.5
6.7	9 40	11 7	10 23.5
6.9	9 43	10 45	10 14.0
		Mean	10 21.0

Least observed light, $7^{M}.1$.

1895 March 3; eleven observations, from 7^{h} 30^{m} to 10^{h} 30^{m}.

Time of minimum from single curve, 9^{h} 23^{m}, wt. 3.

The observations from which this minimum is deduced are incorporated in the following normal minimum, and the mean curve and equal-light reductions are omitted, on account of the deficiency of observations on the increase, caused by a cloudy interval.

Normal minimum, referred to Epoch 2584.

1895 Mar. 3	decrease	11 obsns.;	increase	1 obsn.
19			"	8 "
28	"	8 "		
		19		9

Time of minimum by single curve, 1895 March 17, $5^h\ 31^m.5$, wt. 5.

Time of minimum by mean curve, 1895 Mar. 17, $5^h\ 33^m.3$.

3407 *S Antliae.*

Four minima:

1894 March 7; thirteen observations, from $8^h\ 6^m$ to $11^h\ 10^m$.

Time of minimum by single curve, $10^h\ 18^m$, wt. 4.

Time of minimum by mean curve, $10^h\ 0^m.9$.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
6.9	9 0	11 8	10 4
7.0	9 21	11 2	10 11.5
7.1	9 49	10 29	10 9
		Mean	10 8.2

Least observed light, $7^M.22$.

1895 February 22; thirteen observations, from $9^h\ 30^m$ to $12^h\ 5^m$.

Time of minimum by single curve, $11^h\ 5^m$, wt. 4.

Time of minimum by mean curve, $11^h\ 4^m.3$.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
7.0	10 34	11 34	11 4
7.1	10 48	11 20	11 4
		Mean	11 4

Least observed light, $7^M.14$.

1895 February 23; fourteen observations, from $8^h\ 39^m$ to $11^h\ 43^m$.

Time of minimum by single curve, $10^h\ 44^m$, wt. 4.

Time of minimum by mean curve, $10^h\ 36^m.8$.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
7.0	9 48	11 32	10 40
7.1	10 6	10 59	10 32.5
		Mean	10 36.3

Least observed light, $7^M.16$.

1895 March 9; eight observations, from $7^h\ 25^m$ to $9^h\ 25^m$.

Time of minimum by single curve, $8^h\ 47^m$, wt. 4.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
7.1	8 10	9 25	8 47.5
7.2	8 25	9 20	8 52.5
		Mean	8 50.0

Least observed light, $7^M.29$.

This minimum was observed at full moon, with the $4\frac{1}{4}$-inch telescope.

Dorchester, Mass., 1895 *September* 12.

NOTE ON THE ORBIT OF η *CASSIOPEAE*,

By T. J. J. SEE.

In no. 343 of the *Astronomical Journal*, I have discussed the orbit of *η Cassiopeae*, and for the present position of the companion have relied upon measures of position-angle recently obtained by several observers. My subsequent observations in Virginia (*A.J.* 349) show that the position-angle is smaller, and the distance larger than I had supposed, and hence the elements need a slight correction. We are thus led to the following elements, which represent all the observations in a very satisfactory manner:

$$
\begin{aligned}
P &= 195.76 \text{ years}\\
T &= 1907.84\\
e &= 0.5142\\
a &= 8''.2128\\
\Omega &= 46^\circ.1\\
i &= 45^\circ.95\\
\lambda &= 217^\circ.87\\
n &= +1^\circ.83899
\end{aligned}
$$

Apparent orbit:

Length of major axis = 15″.80
Length of minor axis = 10″.24
Angle of major axis = 55°.8
Angle of periastron = 74°.5
Distance of star from center = 3″.80

The University of Chicago, 1895 *August* 10.

An ephemeris for the next five years is:

t	θ_c	ρ_c
	°	″
1896.50	207.6	4.73
1897.50	210.1	4.68
1898.50	213.7	4.62
1899.50	217.2	4.55
1900.50	221.1	4.46

The parallax of this system recently obtained by Mr. HERMAN S. DAVIS of Columbia College, seems to be entitled to great weight; and yet the value is so large that with these elements the mass is only 0.166 of the mass of the sun. The distance of the system is 164540 times the distance of the earth from the sun, and the semi-major axis of the orbit is 18.539 astronomical units. This mass is very small compared to the values hitherto assigned to this star, but the change may not be greater than will be found to result elsewhere when the parallaxes are critically investigated. The parallax of this system is of such great interest as to justify confirmation by a series of heliometer measures. If this small mass is confirmed by some other independent determination of parallax, our ideas of the nature of the stellar systems will have to be considerably modified.

RESEARCHES ON THE ORBIT OF ζ *SAGITTARII*,

By T. J. J. SEE.

The bright naked-eye star ζ *Sagittarii* was found by Professor WINLOCK many years ago to be a close double star, with nearly equal components. Owing to the great southern declination of ζ *Sagittarii*, which renders it inaccessible to European observers, and makes observation difficult even in the United States, the pair was comparatively neglected for a number of years. The first observation is the work of a single night, and was secured by NEWCOMB with the 9-inch refractor at Washington, in 1867. The pair was not again observed until 1878, when BURNHAM began to give it regular attention. His series of measures now show that ζ *Sagittarii* belongs to the class of bright close binaries with short periods. This object has therefore become one of particular interest to American observers.

The first investigation of the orbit was made by Mr. J. E. GORE, who published the following elements (*Monthly Notices, R. A. S.*, 1886, p. 444):

$P = 18.69$ years
$T = 1882.86$
$e = 0.1698$
$a = 0''.53$
$i = 58^\circ.8$
$\Omega = 83^\circ.37$
$\lambda = 263^\circ.35$

Mr. J. W. FROLEY has more recently examined this orbit and obtained a set of elements (*Astronomy and Astrophysics*, June 1893), which do not require any large correction:

$P = 17.715$ years
$T = 1878.62$
$e = 0.30$
$a = 0''.68$
$\Omega = 75^\circ.35$
$i = 73^\circ.95$
$\lambda = 327^\circ.35$

While in Virginia recently, I took occasion to measure this star, and, although the object was seen with difficulty, owing to its low altitude, I could discover a distinct elongation in the direction 194°.7; the distance could not be fixed with much confidence, but my settings of the micrometer gave 0″.35. The estimates of distance were substantially the same, but I am now convinced, from my distinct recollection of the appearance of the object, that both the measure and the estimate were too large. The star could not be separated, although it was sharply elongated with a power of 1300; the distance was probably less than 0″.25.

From an examination of all the measures of this pair I have derived the following elements:

$P = 18.85$ years
$T = 1878.80$
$e = 0.279$
$a = 0''.686$
$\Omega = 69^\circ.3$
$i = 67^\circ.32$
$\lambda = 328^\circ.1$
$n = -19^\circ.098$

Apparent orbit:

Length of major axis	= 1″.300
Length of minor axis	= 0″.423
Angle of major axis	= 74°.8
Angle of periastron	= 82°.8
Distance of star from center	= 0″.168

COMPARISON OF COMPUTED WITH OBSERVED PLACES.

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
	°	°	″	″	°			
1867.80	260.8	254.8	0.48	0.81	+ 6.0	−0.33	1	Newcomb
1878.70	81.2	85.6	0.42	0.41	− 1.4	+0.01	1	Burnham
1879.71	54.8	69.4	0.3 ±	0.48	−14.6	−0.18	1	Burnham
1880.62	62.1	57.7	0.55	0.42	+ 4.4	+0.13	2	Burnham
1881.61	36.1	42.2	0.31	0.33	− 6.1	−0.02	2	Burnham
1886.62	271.3	273.7	0.65	0.59	− 2.4	+0.06	1	Hall
1888.66	259.3	260.9	0.67	0.79	− 1.6	−0.12	7	Burnham, 6; Leavenworth, 1
1889.41	255.1	256.7	0.81	0.81	− 1.6	±0.00	5	Burnham
1890.49	251.1	251.7	0.76	0.78	− 0.6	−0.02	3	Burnham
1891.53	246.5	246.5	0.61	0.70	± 0.0	−0.09	3	Burnham
1892.39	245.1	241.8	0.60	0.60	+ 3.3	±0.00	3	Burnham
1895.32	194.7	191.3	0.35	0.22	+ 0.4	+0.13	3	See

When we consider the small number of observations, and the discordant character of some of the measures, we must regard these elements as highly satisfactory. It is not likely that they will be materially changed by future observations; but for some time this rapid binary will deserve careful attention. The eccentricity of the orbit appears to be fairly well defined, and is rather smaller than usual; good observations during the next five years will enable us to fix this element with the desired precision. The star is now very difficult, and will remain so for several years, but it is constantly within reach of our large refractors.

The following is a short ephemeris:

t	θ_c	ρ_c
	°	″
1896.50	118.1	0.24
1897.50	76.5	0.47
1898.50	63.5	0.46
1899.50	49.8	0.37
1900.50	29.9	0.28

The University of Chicago, 1895 *Aug.* 10.

ELEMENTS AND EPHEMERIS OF COMET *a* 1895 (SWIFT),

BY A. O. LEUSCHNER.

The following elements computed by Prof. A. O. LEUSCHNER assisted by Mr. W. H. WRIGHT, from observations made by Prof. E. E. BARNARD, Aug. 21, 22 and 23, were received by mail. Although telegraphed from California, Aug. 26, their publication was delayed, owing to three wrong words in the telegram.

$$T = 1895 \text{ August } 16.4510 \text{ Gr.M.T.}$$

$$\left.\begin{array}{rl} \omega = & 164^\circ\ 1'\ 33'' \\ \Omega = & 172\ 32\ 40 \\ i = & 3\ 38\ \ 4.5 \end{array}\right\} \text{Mean Equin. 1895.0}$$

$$\log q = 0.142716$$

Correction to ephemeris Sept. 3 (from obs. by Prof. BOSS, Albany) was +15ˢ and −0′.7

ON TWO RECENTLY ANNOUNCED VARIABLES,

BY PAUL S. YENDELL.

(7084) — *Lyrae.*

R.A. = 19ʰ 3ᵐ 23ˢ.6 Decl. = + 29° 25′.8 (1855)

This is ANDERSON'S star, noticed by him in the *Astronomische Nachrichten*, no. 3279. I have observations as follows:

1895 April	3	not seen; limit <12 mag.
May	16	" " " 12 " ±
July	23	" " " <12 "
Aug.	16	" " " 12 "
Sept.	14	9.1 mag.
	15	9.1 mag.

The star is certainly variable.

Dorchester, 1895 *September* 17.

7999 *X Aquarii.*

To the best of my knowledge, the only confirmation of this star's variability has been that of PICKERING, from the photographs on whose indications the original announcement was based. I have five observations, which completely confirm its variability; they are as follows:

1895 July	28	8.7 mag.
	30	8.8 "
Aug.	16	9.6 "
	21	9.6 "
Sept.	14	not seen; limit <11 mag.

OBSERVATIONS OF COMET *a* 1895,

MADE AT THE DUDLEY OBSERVATORY, ALBANY, N.Y.

BY LEWIS BOSS.

1895 Albany M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Sept. 14 13 11 11	4	11, 8	+0 3.45	+3 18.8	1 12 33.83	+5 50 31.6	*n*8.685	0.722
17 13 28 52	5	8	+1 13.87	+2 26.3	1 15 34.59	+5 39 27.1	7.308	0.724
19 13 24 35	5	9	+2 57.66	−5 40.8	1 17 18.40	+5 31 20.1	7.711	0.725
24 12 18 44	6	13, 10	−0 10.92	+2 42.2	1 20 45.63	+5 9 3.5	*n*8.948	0.700

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
4	1 12 26.78	+3.60	+5 46 47.2	+25.6	See note below
5	1 14 17.07	+3.65 +3.67	+5 36 34.9	+25.9 +26.0	Piazzi 46. Rümk. 592. Paris 1673 (R.A.)
6	1 20 52.78	+3.77	+5 5 54.9	+26.4	A G., Albany 396

Sept. 14, *4 — *5; $\Delta\alpha = -1^m\ 50^s.36$; $\Delta\delta = +10'\ 13''.1$. Also, *4 — Paris 1666; $\Delta\alpha = -1^m\ 32^s.38$; $\Delta\delta = -2'\ 16''.1$.

The observations are made with illuminated threads. Sept. 24, the comet seemed rather brighter than on previous occasions; possibly this may have been due to more transparent air.

NEW ELLIPTIC ELEMENTS AND EPHEMERIS OF COMET *a* 1895 (*SWIFT*),

By LEWIS BOSS.

Epoch 1895 August 24.5 Greenw. M.T.

$M = 0^\circ\ 30'\ 41''.12$
$\omega = 167\ 42\ 19.3$)
$\Omega = 170\ 18\ \ 6.8$ } 1895.0
$i = 3\ \ 0\ 11.1$)
$\varphi = 40\ 14\ 17.2$
$\mu = 191''.590$
$\log a = 0.572269$; Period = 7.22 years

Ephemeris for Greenwich Midnight.

1895	App. α	App. δ	log Δ
	h m s	° ′ ″	
Oct. 6.5	1 25 11.1	+4 15 20	9.6224
8.5	25 34.1	4 7 12	9.6316
10.5	25 52.8	3 59 36	9.6413
12.5	26 8.3	3 52 37	9.6513
14.5	26 21.4	3 46 20	9.6617
16.5	26 33.0	3 40 48	9.6724
18.5	26 44.0	3 36 5	9.6835
20.5	26 55.2	3 32 11	9.6949
22.5	27 7.3	3 29 18	9.7065
24.5	27 21.0	3 27 17	9.7184
26.5	27 36.8	3 26 13	9.7305
28.5	27 55.3	3 26 5	9.7428
30.5	28 16.8	3 26 52	9.7552
Nov. 1.5	28 41.7	3 28 34	9.7678
3.5	29 10.2	3 31 9	9.7805
5.5	29 42.5	3 34 36	9.7933
7.5	1 30 18.8	+3 38 53	9.8062
Nov. 9.5	1 30 59.3	+3 43 59	9.8192
11.5	1 31 44.1	+3 49 53	9.8322

Comparison with Observation (O—C).

Mount Hamilton.

	$\Delta\alpha$	$\Delta\delta$
	s	″
Aug. 21	+0.98	− 7.1
22	+0.67	− 0.8
23	+0.37	− 9.7
24	+0.70	+ 0.5
26	+0.12	− 0.8
27	+0.51	+ 7.3

Leipsic.

	$\Delta\alpha$	$\Delta\delta$
Aug. 25	+0.87	− 2.2
28	−1.22	−13.2
29	+0.15	− 5.7

Nice.

	$\Delta\alpha$	$\Delta\delta$
Aug. 24	−0.32	+ 3.0
25	−0.56	− 2.7
27	−0.09	+ 0.7
28	−0.25	− 1.7
29	+0.22	+ 0.1
30	+0.02	+ 2.2
31	+0.29	− 2.2

Northfield.

	$\Delta\alpha$	$\Delta\delta$
	s	″
Aug. 23	+0.17	+2.7
25	+0.39	+0.7
28	+0.62	−4.5
30	+0.31	−2.1

Charlottesville.

	$\Delta\alpha$	$\Delta\delta$
Aug 23	−0.40	−0.6
25	+0.07	−0.9
27	+0.73	−0.6

Albany.

	$\Delta\alpha$	$\Delta\delta$
Aug. 24	−0.13	+2.6
25	−0.10	+4.4
31	+0.20	−2.3
Sept. 3	−0.31	−2.0
14	+0.03	+0.7
17	−0.02	−0.1
19	+0.09	−0.7
24	+0.37	−4.7

NOTE UPON THE PROBABLE ERRORS OF MERIDIAN OBSERVATIONS IN DECLINATION,

By TRUMAN HENRY SAFFORD. Field Memorial Professor of Astronomy in Williams College.

In preparing a rather extensive catalogue of latitude-stars for the Mexican Boundary Commission, I found that the practice of astronomers in assigning relative weights to different authorities in declination varies widely, and that the subject is so far advanced that a knowledge of these weights is important.

A memoir now in press deals with the question of the ultimate accuracy of standard catalogues of declination; in the present paper I shall take up the probable error of the single deliberate meridian observation according to the present highest standards. The best normal inquiry into this matter, with which later developments can be compared, I found to be Professor Gyldén's reduction of C. A. F. Peters's series of standard declinations observed at Pulkowa in 1842–1849.

Gyldén's memoir, contained in vol. 5 of the "*Observations de Poulkova*," was published in 1873, and is later in date than his own observations, which, with Nyrén's continuation, furnish the standard for the declinations of the *Astronomische Gesellschaft*; the mean epoch is about 1865. The probable error (r_1) of a single, or as it is called at Pulkowa, an incomplete observation, is expressed by the radical

$$\sqrt{\sigma^2+\rho^2+\zeta^2}$$

Here σ is the probable error of setting and reading off; ρ the probable difference between the actual refraction and that which is computed from the indication of the meteorological instruments; and ζ the probable error of the zenith-point used in the reduction. The Pulkowa standard zenith-distances are, as is well known, measured with an altazimuth; and in the normal use of the instrument the probable error ζ is much diminished by immediate reversal of the instrument, by a half rotation about its vertical axis, and reobservation of the star in this position, at the same culmination. Hence the probable error (r) of a double, or as the Pulkowa astronomers calls it, a *complete* observation, becomes

$$\sqrt{\tfrac{1}{2}\sigma^2+\rho^2+\eta^2}$$

There σ and ρ are the same as before, and η is the residual probable error of the zenith-point, due mainly to slight strains in turning the instrument around, or perhaps slight influences of temperature upon the level.

The values of ζ, η, derived by Professor Gyldén, are respectively ±0″.30 and ±0″.11; that of σ varies from ±0″.24 at the zenith to ±1″.13 at a zenith-distance of 85°; it is ±0″.335 at 45° from the zenith, and ±0″.48 at 60°. The value of ρ was found by Fuss, in agreement with Argelander's observations at Königsberg, to increase very rapidly near the horizon; the expression for it is a little complicated, and depends upon the refraction itself.

One consequence of this peculiarity is that the ordinary discussion of the probable errors of observed zenith-distances by the formula

$$\sqrt{a^2+b^2\tan^2 z}$$

gives for ordinary good observation, at moderate zenith-distances, too large a value of r if the observations near the horizon are included in determining it; and to fairly compare two series, the observations should be used within the same range of zenith-distance.

In order then to diminish as much as possible the probable error of an observed declination or zenith-distance the effort should be to diminish the separate elements, σ, ρ, ζ, η. The Pulkowa vertical circle enables ζ to be brought down from 0″.30 to 0″.11 (or η) by a double observation; and Bessel accomplished a similar result in his last series of declinations, completed just before his decease, by observing the nadir with every star, or nearly so.

These methods are of course adapted to standard stars only, as they consume a great deal of time.

For ordinary observations the zero of declinations can be kept under rigid control by well-determined standard stars. This process has been most thoroughly carried out at Berlin, by Professors Becker and Küstner, and Dr. Battermann. In Becker's catalogue of 521 Bradley stars (Berlin, 1881), we find that the quantity ρ has been made almost entirely to disappear. A careful study of hints in the Berlin reports makes plain that this is accomplished by employing a relatively large number of standard stars, thoroughly interwoven with the stars to be determined. In fact, the method is an adaptation of that contained in the programme of the *Astronomische Gesellschaft* for the great catalogue. Here the number of zero-stars required is about 4 to a zone. Professor Becker gives 6 as the average number for his catalogue.

The quantity σ can of course be diminished by more settings and readings-off, by greater care in bisection, or by improvements in the illumination of the field and the limb. Fairly to compare the Pulkowa absolute declinations with Becker's relative ones, we must quote from the results of Gyldén's and Nyrén's later tables of probable errors. The value of the probable error for the declinations of a complete observation 10° to 56° is now ±0″.22 on the average, compared with numbers varying from ±0″.21 to ±0″.31 in 1842 to 1849. From 10° to —5°, or zenith-distances 50° to 65°, the former values varied between ±0″.31 and ±0″.47; they are now on the average ±0″.27; between —5° and —16° of declination, or 65° and 76° of zenith-distance, the former average was somewhere between ±0″.47 and ±0″.69, now is ±0″.41. All these values indicate the effect of greatly increased attention on the observer's part to the circumstances of the single observations.

If then we compare the Pulkowa tables of errors in their present shape with Becker's, we are at once impressed with the fact that the single relative observation at Berlin is equally accurate with the double or complete absolute observation at Pulkowa; this indicates of course that the quantity ρ, the variation of refraction from its normal amount, has been thoroughly eliminated by zero-stars near the parallel of the stars to be determined.

On the other hand it must be remembered that the casual errors of the standard catalogue pass over into systematic and constant errors in the more numerous star-places determined from them; so that as the latter results become more important, the care for absolute positions must be more and more increased.

With the Pulkowa meridian circle the results obtained in 1874 to 1880 by Romberg are of very great importance. These are relative and based upon the work with the vertical circle; but in such a manner as to practically re-determine the individual fundamental declinations, by the use of Pond's method. In consequence of this, both advantages are partially gained. The elimination of ρ is not entirely effected, but it is greatly diminished south of the equator, where it is most troublesome; and the determining stars are so many that their individual errors in declination have very little effect.

The probable error of a single observation is about ±0″.34; greater than with Becker, and less than in the incomplete observations with the vertical circle by Nyrén, which, at the zenith give ±0″.38. Becker's value at this point is ±0″.26.

The size of an instrument has a well-defined influence on its accuracy, but one which is less marked than is usually supposed. A large meridian circle does not of itself produce accurate results, nor a small one those which are seriously inaccurate. Two marked examples of good work are the observations of Professor Valentiner at Karlsruhe, and Professor Becker at Gotha. The former was placed in charge of the old and defective observatory at Mannheim. After removal to a temporary building at Karlsruhe, he employed a Reichenbach repeating-circle reconstructed into a meridian circle, with 3¼-inches aperture, his single observations at a zenith-distance of 50° and more have a probable error of ±0″.40. Becker completed, with a small and old circle at Gotha, the reobservation of Mayer's stars not in Bradley: this is well known to all who have read Professor Auwers's admirable edition of Mayer, as an excellent and thoroughly accurate piece of work; hardly second in importance and precision to his catalogue of Bradley's neglected stars.

The extreme accuracy of the zenith telescope in Wanschaff's construction is also a proof that an object-glass of 3 inches in aperture, even with the shorter focal length now in fashion, is not too small to produce extremely precise results; and that the repetition of bisections at the same culmination allows an increase of accuracy, and a diminution of the quantity denoted by σ in Gyldén's memoir.

All things considered, the most useful meridian circle is probably one of about 12cm. in aperture, and 1.5m. of focal length; but constructed in such a manner with central illumination of field and limb that no additional error shall arise or be made possible thereby. The original construction of the great Washington circle, like that of the Leyden one, is faulty in this point; and in both cases anomalous results have been noticed, and the precision attained has been at times far below that which is desirable. It seems possible, however, by continual watching of the focal adjustments, greatly to mitigate this evil; the larger Berlin meridian circle seems to have been used by Becker in the same condition, and the fault corrected in current work; the later reconstruction of the Berlin and Leyden instruments renders it easier to obtain precise results, which before was not impossible, but merely difficult. Foerster had investigated the whole problem of the illumination of micrometer-points, and it is to be presumed that his researches were available.

We can now understand Prof. Kaiser's disappointment at the lack in precision of his great series of declinations. This seems to be entirely accidental, and confined to the individual observations; and the especial point which attracted his attention was the wide variations as to probable error between different stars and different observers. With 16 observations to a star the probable error of the probable error would be $\frac{0.476}{\sqrt{15}} = 0.12$ of the probable error itself. The fact that this amount was exceeded by the comparison *inter se* of the probable errors of individual stars indicates of course that the latter actually varied from time to time in the series. In other words, when the focal adjustment was bad, owing to change of temperature or other accidental causes, the probable error of a declination would be large; while it would be small if the focal plane of the object-glass returned nearly to the plane of the wires.

We now, thanks to Foerster's investigation, know that a perfectly central illumination relieves us from extreme anxiety about the focal adjustments; but we do not yet know the effect on probable errors of a disregard of this principle. The eccentric results obtained at the Washington Naval Observatory during some years of the use of the great meridian circle afford abundant examples; but I do not know whether there is sufficient material in them for a full investigation.

It may be well, in conclusion, to give the most available values of the probable error of a single declination at the zenith-distance 45°; zone observations are here omitted, so that the probable error is one which corresponds to thoroughly deliberate work.

Class 1. Mural quadrants.

Bradley,	±0″.81	Mayer,	±0″.93

Class 2. Reichenbach circles with verniers.

Bessel,	±0″.71	Argelander,	±0″.96
Struve,	±0 .60	Preuss,	±0 .82
Doellen,	±1″.07		

The last value is large, probably because the limbs were tarnished by long use; a circumstance which naturally affects vernier readings far more than microscopic. The observations were made half a century ago at the beginning of Doellen's long and admirable experience.

Class 3. Mural circles.

Pond-Olufsen,	±0″.54	Challis,	±0″.56
Pond-Chandler,	±0 .47	Henderson, 1831–37	±0 .50
Paris 1852 (Laugier),	±0″.42		

Class 4. English meridian circles before 1850.

Armagh,	±0″.89

Class 5. English meridian circles (Airy's construction).

Greenwich (Marth),	±0″.64	Cape of Good Hope,	±0″.51
Greenwich (Stone),	±0 .60	Radcliffe (Stone),	±0 .5

Class 6. German and American meridian circles with microscopes.

Bessel,	±0″.55	Romberg,	±0″.31
Sabler,	±0 .52	Becker,	±0 .28
Doellen	±0 .50	Valentiner,	±0 .40
Winnecke,	±0 .49	Küstner,	±0 .28
Leyden,	±0 .50	Brown and Flint,	±0 .36
Engelmann,	±0 .46	Battermann,	±0 .35
Porter,	±0″.55		

Class 7. The Pulkowa vertical circle.

Peters, double obs.,	±0″.28	Nyrén, '72, double obs.	±0″.29
Gyldén, " "	±0 .23	Nyrén, '85, " "	±0 .23

It is to be noted that the numbers given for Engelmann, Romberg, Becker, Valentiner, Küstner, Battermann and Porter, refer to relative observations; in the first two and the last cases, however, the zero-stars are spread over a large range of zenith-distance; and Valentiner had an exceptionally small instrument.

In Dr. Chandler's paper the observations with the vertical circle which are double only, with a single instrument and observer, on a single date, are compared with Pond's, which require for a complete determination (with a probable error of ±0″.2) two circles, two observers, and two dates; the proper term of comparison, on the side of the Pulkowa instrument, would be the observations of *Polaris*, where probable error is but ±0″.16. We should need in this case to suppose that a long enough time is spent on *Polaris* to reduce Gyldén's ρ to the result of the four different values of the same quantity involved in the Greenwich observation.

Hyannis, Mass., 1895 *July* 18.

OBSERVATION OF TOTAL ECLIPSE OF MOON, 1895 SEPTEMBER 3,

WITH 9½-INCH EQUATORIAL OF SCHOOL OF SCIENCE OBSERVATORY, PRINCETON, N.J.,

By TAYLOR REED.

The observations were made with clear sky and fair seeing. During partial phase the eclipsed portion of the moon could be readily seen. At all the occultations the limb could be clearly seen in the telescope. From 17h 10m to 17h 30m G.M.T., the northern half of the moon seemed, as seen in the finder of the telescope, much more reddish than the southern half.

Eight occultations of stars were observed, six immersions, and two emersions. The times were all taken by chronograph.

Star		Observed Pr. Sid. T.	Estim. Late	Estimated Gr. M.T.	
		h m s	s	h m s	
W. Bessel XXII, 987	Imm.	22 39 15.5	0.2	16 45 48.9	Good
" XXII, 1006	Imm.	23 19 38.9	0.4	17 25 55.5	Good
W. Bessel XXII, 1002	Em.	23 34 31.0	0.6	17 40 45.0	Not v.g.
DM. 8 5985,	Imm.	23 39 10.1	0.4	17 45 23.5	Only fair
Anonymous,	Imm.	23 43 14.4	0.4	17 48 27.3	Fair
DM. 8°5987,	Imm.	0 8 37.1	0.2	18 14 46.1	Good
DM. 7°5896,	Imm.	0 23 26.5	0.2	18 29 32.9	v. sharp
DM. 8°5985,	Em.	0 38 36.4	0.5	18 44 19.7	Fair

A rough measure made on Sept. 5 gives, for the position of the star marked "Anonymous," 42s.5 following, and 4′ 15″ north of W.B. XXII, 1006; apparent place 22h 51m 19s, −7° 52′.2.

The error of the clock was determined from three stars about the time of the beginning of the eclipse.

RETURN OF FAYE'S COMET.

A telegram from the Central Institute at Kiel brings word that the periodic comet of Faye has been found and observed:

Sept. 26.5039 Greenw. M.T. $\alpha = 21^h\ 8^m\ 11^s.5$. $\delta = -1°\ 54'\ 14''$.

A finding ephemeris, computed by Engström from Möller's elements in the Berlin *Jahrbuch* for 1882, may be found in no. 3306 of the *Astronomische Nachrichten.*

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Observations of Comet a 1895, by Prof. Lewis Boss.
New Elliptic Elements and Ephemeris of Comet a 1895 (Swift), by Prof. Lewis Boss.
Note upon the Probable Errors of Meridian Observations in Declination, by Prof. T. H. Safford.
Observation of Total Eclipse of Moon, 1895 September 3, by Prof. Taylor Reed.
Return of Faye's Comet.

Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office at Boston, Mass., as second-class matter. *Closed October 2.*

THE

ASTRONOMICAL JOURNAL.

No. 356.

VOL. XV. BOSTON, 1895 OCTOBER 16. NO. 20

RESEARCHES ON THE ORBIT OF *O*Σ 285,

BY T. J. J. SEE.

This close double star was discovered in 1845 by Otto Struve, who measured the companion several times during the next few years. The other early measures were by Mädler and Secchi, while in later years the pair has been measured only by Engelmann, Schiaparelli, Burnham and the writer. Thus, only a small number of observations are available for the determination of an orbit, but it happens that these are distributed so as to give a fairly good set of elements.

The star has always been a difficult object, and hence the measures are necessarily less accurate than in case of easier stars. Burnham was the first to attempt an investigation of the orbit of this pair (*Sidereal Messenger*, June, 1891). His apparent ellipse and the resulting elements are not very different from those found in this paper. Mr. Gore has since attempted an orbit by a very different process, and obtained results of a wholly different character (*Monthly Notices*, April, 1893). These two sets of elements are:

	Gore	Burnham
$P =$	118.57 years	62.1
$T =$	1881.93	1885.3
$e =$	0.58	0.429
$a =$	0″.46	0″.387
$\Omega =$	107°.0	54°.3
$i =$	45°.7	44°.3
$\lambda =$	161°.4	180°.0

Using all the measures, and basing the work on both angles and distances, I find the following elements of *O*Σ285:

$P = 76.67$ years
$T = 1882.53$
$e = 0.470$
$a = 0''.3975$
$\Omega = 62°.2$
$i = 41°.95$
$\lambda = 162°.23$
$n = -4°.6953$

Apparent orbit:

Length of major axis	= 0″.788
Length of minor axis	= 0″.522
Angle of major axis	= 67°.1
Angle of periastron	= 255°.3
Distance of star from center	= 0″.182

The following table of computed and observed places shows that the measures are represented as well as could be expected in case of an object of this difficulty.

t	θ_0	θ_c	ρ_0	ρ_c	$\theta_0-\theta_c$	$\rho_0-\rho_c$	n	Observers
	°	°	″	″	°	″		
1845.80	72.2	73.2	0.61	0.57	− 1.0	+0.04	3	O. Struve
1847.96	72.2	70.0	0.42	0.57	+ 2.2	−0.15	3	Mädler
1852.71	58.4	62.9	0.49	0.56	− 4.5	−0.07	5	Mädler
1855.84	53.9	58.0	0.51	0.54	− 4.1	−0.03	3	O. Struve
1857.50	65.5	55.1	0.40	0.52	+10.4	−0.12	1	Secchi
1865.53	36.0	38.4	–	0.42	− 2.4	–	1	Dembowski
1876.40	350.0	357.4	0.3 ±	0.24	− 7.4	+0.06	1	Burnham
1881.50	–	267.6	doubtful	0.20	–	–	1	Burnham
1883.84	258.3	241.0	0.22	0.21	+17.3	+0.01	5	Engelmann
1887.60	202.2	203.6	0.24	0.22	− 1.4	+0.02	4	Schiaparelli
1891.30	168.7	170.1	0.24	0.24	− 1.4	±0.00	3	Burnham
1892.30	162.2	162.0	0.24	0.25	+ 0.2	−0.01	3–2	Burnham
1893.46	156.0	153.2	0.24	0.26	+ 2.8	−0.02	1	Burnham
1895.32	147.3	142.0	0.30	0.28	+ 5.3	+0.02	3	See

The only large residual is that of **Engelmann**, whose small telescope would necessarily render his observations subject to considerable uncertainty. Indeed, he gives the angle as 78°.3, but I have assumed that he really saw the companion, and have therefore changed the angle by 180°. The estimate of 36° for the position-angle in 1865.53 is very nearly correct, and leaves no doubt that the elongation observed by **Dembowski** was real.

When I measured the object recently with the 26-inch refractor of the Leander McCormick Observatory in Virginia, the stars were not separated, except on one night, and hence the difficulty of the pair will doubtless account for the error in angle. The star is slowly separating, and ought to be observed annually. The following is an ephemeris for the next five years.

t	θ_c	ρ_c
	°	″
1896.40	135.6	0.30
1897.40	130.7	0.32
1898.40	126.5	0.33
1899.40	122.3	0.35
1900.40	118.4	0.36

The comparatively long period of this close star may probably be construed to mean that the system is very remote from the *Earth*, otherwise the mass would be excessively small. The eccentricity of the orbit is fairly well defined, and is near the mean value of this element among double stars.

The University of Chicago, 1895 *September* 3.

OBSERVATIONS OF MINOR PLANET (372),

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY MARY W. WHITNEY AND CAROLINE E. FURNESS.

1895 Greenwich M.T.	*	No. Comp.	Planet — * $\Delta\alpha$	Planet — * $\Delta\delta$	Planet's apparent α	Planet's apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ	Obs.
h m s			m s	′ ″	h m s	° ′ ″			
April 11 15 51 56	1	7	−0 3.65	+4 36.8	7 57 36.57	+24 58 4.4	9.664	0.615	F
17 16 19 55	2	7	−0 0.94	−4 9.7	8 3 13.26	+23 52 9.9	9.681	0.705	F
17 19 41	2	6	+0 0.17	−4 18.9	8 3 14.37	+23 52 0.7	9.683	0.734	W
18 15 14 58	3	5	−1 9.46	−5 31.5	8 4 8.01	+23 42 9.7	9.624	0.609	W
15 34 24	3	9	−1 8.59	−5 40.3	8 4 8.88	+23 42 0.9	9.643	0.630	F
19 15 49 51	4	10	−0 7.56	+7 6.8	8 5 7.77	+23 31 5.2	9.656	0.651	F
23 14 48 40	5	12	+0 46.09	+9 52.1	8 9 10.63	+22 48 51.2	9.608	0.605	F
25 16 0 59	6	6	+1 26.49	−2 28.0	8 11 22.57	+22 27 9.8	9.668	0.687	F

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	7 57 38.80	+1.42	+24 53 21.4	+6.2	Astr. Gesell., Berlin
2	8 3 12.83	+1.37	+23 56 13.9	+5.7	Bonn VI
3	8 5 16.10	+1.37	+23 47 35.6	+5.6	Romberg 1831
4	8 5 13.99	+1.34	+23 23 52.8	+5.6	Micrometric comparison with Romberg 1841
5	8 8 23.28	+1.26	+22 38 53.8	+5.3	Astr. Gesell., Berlin
6	8 9 54.84	+1.24	+22 29 32.6	+5.2	Paris 10097

NOTES ON VARIABLE STARS, — No. 10,

BY HENRY M. PARKHURST.

R Comae. In consequence of the difficulty of observation in the twilight with a variable sky, I have sometimes dispensed with the transit-wire, observing the interval between the disappearance of the variable and that of the comparison-star; eight such comparisons being recorded as a double observation of each star. When the sky was especially uncertain, I made several additional pairs of observations, and rejected an equal number of the highest and lowest counts as presumably vitiated by the cloudiness. On several dates I also obtained a double observation with the transit-wire and four comparison-stars. The two methods closely agreed.

From the light-curve shown by my observations in *A.J.* 326, and from the observations in each of the four years given in the table below, I obtained the corresponding approximate maxima. Taking the epoch in 1831, I obtained the formula $2389922.3 + 357.50\,E + 0.06\,E^2$, with which the comparisons in the table are made In consequence of the interruptions in the observations of 1894 and 1895, it is probable that the coincidence of this year is partly accidental. Yet the eastern elongation appears to have been reached.

If the above formula should be replaced by a sine-formula, which is usually more reliable, it will modify my conclusions in *A.J.* 326. The corrections given in the table also represent very nearly the comparison with the sine-formulas best representing the inconsistent observations of 1856 and 1857; and both these formulas indicate that the maximum will not occur many days later than at present.

Y Bootis. The times given in the table below are the lowest points during the long series of continuous observations, which are so grouped in the table of individual observations as to avoid counterbalancing errors; but no satisfactory minimum was observed, the sky being usually unreliable, and the observed depressions brief and uncertain. The sine-formula given in *A.J.* 329 has not been confirmed.

Min.	Date		E	Corr.
3258.611	March	5	119	−0.010
3271.627		18	124	− .026
3284.557		31	129	− .042
3323.606	May	9	144	− .042
3344.597		30	152	− .009
3443.542	Sept.	6	190	+0.020

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date		E	Corr.	W	Remarks
			Julian	Calendar 1895				
3712	*U Leonis*	–	–	–	–	–	–	Probably not variable
3881	*V Hydrae*	Max	3334	May 20	14	+51	6	Curve flat and irregular
3994	*S Leonis*	Max	3268	Mar. 15	66	−18	3	
"	"	Min	3355	June 10	67	–	–	From elements
4160	*T Leonis*	Min	3318	May 4	–	–	8	Assumed 3s5f DM.+4°2505. Fluctuation; period uncertain
4300	*X Virginis*	–	–	–	–	–	–	Probably fluctuates somewhat
4315	*R Comae*	Max	9039	Aug. 16	53	+0.7	1	1883; from light-curve; see note above
"	"	Max	9402	Aug. 13	54	−0.3	1	1886; see H.C.O. Annals, vol. XXIX
"	"	Max	0494	Aug. 10	57	−0.8	1	1887; see H.C.O. Annals
"	"	Max	1955	Aug. 10	61	+1.9	1	1891; see H.C.O. Annals
"	"	Max	3048.1	Aug. 7	64	0.0	9	1894, *A.J.* 326
"	"	Max	3413.2	Aug. 7	65	−0.1	9	1895
4377	*T Virginis*	Min	3284:	Mar. 31	37	–	–	Approximation from elements; invisible at least three months
4407	*R Corvi*	Max	3358.3	June 13	31	+29	9	
4596	*U Virginis*	Max	3316	May 2	51	−19	6	Periodic inequality confirmed
4847	*S Virginis*	Max	3326	May 12	42	− 9	9	Rejecting May 13 would make it later.
5037	*RR Virginis*	Max	3339	May 25	27	− 3	9	
5070	*Z Virginis*	Max	3383	July 8	18	+32	5	Had not appeared 46 days prior to observed max.
5144	*Y Bootis*	–	–	–	–	–	–	See note above
5174	*RS Virginis*	Max	2950	May 1	4	–	–	1894; prediction from elements, *A.J.* 347
"	"	Max	3318	May 4	5	+ 8	6	
5194	*V Bootis*	Min	3403	July 28	16	−15	9	Changes very slow
5237	*R Bootis*	Min	3360	June 15	61	–	–	From elements
"	"	Max	3457	Sept. 20	61	− 4	9	Four comparison-stars fluctuate
5249	*V Librae*	Max	3376	July 1	13	–	–	From elements; evidently at least 4 months in error
5430	*T Librae*	Min	3410:	Aug. 4	27	–	–	Sky too hazy for faint stars
5438	*Y Librae*	Max	3459+	Sept. 22	38	+130	1	First bright max. I have seen; elements astray
5494	*S Librae*	Max	3371	June 26	40	−13	8	
5501	*S Serpentis*	Max	3352	June 7	67	+17	5	
5511	*RS Librae*	Max	3399	July 24	10	−14	8	
5583	*X Librae*	Max	3391	July 16	38	− 9	2	Correction +5 by my elements in *A.J.* 300
5675	*V Coronae*	Max	3332	May 18	17	− 7	5	Cloudy at time of second maximum

INDIVIDUAL OBSERVATIONS.

3712 1893 February, March, April, May, June; 1894 February, March, April, May; 1895 February, March, April, May, June; only a 12$^{\mathrm{M}}$.0 star seen.

3881 *V Hydrae*

(Continued from 326)

Julian	Calendar	Mag.
	1895	
3272.6	Mar. 19	8.3
3287.5	Apr. 3	8.2
3289.6	5	8.03_2
3295.5	11	7.92_2
3301.6	17	8.28_2
3303.6	19	8.08_2
3307.5	23	7.90_2
3316.5	May 2	7.77_2
3321.5	7	7.97_3
3324.5	10	7.86_2
3330.5	16	7.72_2
3342.6	28	8.06_4
3352.6	June 7	8.25_2

3994 *S Leonis.*

(Continued from 326)

Julian	Calendar	Mag.
	1895	
3242.6	Feb. 17	11.3
3272.6	Mar. 19	9.63
3287.5	Apr. 3	10.8
3301.6	17	11.3
3303.6	19	11.75_2
3312.6	28	12.82_2
3324.6	May 10	13.0]

4160 *T Leonis.*

Julian	Calendar	Mag.
	1893-1895	
2511	Feb. 16	11.3]
2530	Mar. 7	11.3]
2558	Apr. 4	12.3
2590	May 6	12.3
2623	June 8	12.3
2870	Feb. 10	11.6]
2914	Mar. 26	11.1
2945	Apr. 26	11.1
2976	May 27	12.5
3242.6	Feb. 17	12.3
3245.6	20	11.6
3272.6	Mar. 19	11.1
3274.6	21	12.51_2
3295.5	Apr. 11	12.39_2
3301.6	17	11.3
3303.6	19	11.81_2
3305.6	21	12.19_2
3307.6	23	12.58_2
3312.6	28	13.11_2
3324.6	May 10	12.5
3326.6	12	12.59_2
3330.6	16	12.29_2
3342.6	28	12.01_2
3362.6	June 17	11.94_2

4300 *X Virginis.*

Julian	Calendar	Mag.
	1893-5	
2511	Feb. 16	11.9
2530	Mar. 7	11.3 :
2536	13	11.6
2558	Apr. 4	11.7
2565	11	12.1
2570	16	11.64_2
2590	May 6	11.2
2593	9	11.65
2623	June 8	11.6
2870	Feb. 10	11.4]
2895	Mar. 7	11.5
2928	Apr. 9	11.8
2948	29	11.9
2976	May 27	11.9
3242.6	Feb. 17	11.0]
3251.5	26	11.2
3270.6	Mar. 17	11.8
3302.6	Apr. 18	11.3
3342.6	May 28	12.0
3359.6	June 14	11.8

4315 *R Comae.*

(Continued from 326)

Julian	Calendar	Mag.
	1895	
3364.6	June 19	12.0]
3370.6	25	11.9]
3385.6	July 10	11.5
3403.6	28	10.25_2
3405.6	30	10.24_2
3408.6	Aug. 2	9.75_3
3414.6	8	9.67_4
3416.6	10	10.01_2
3418.6	12	9.82_4
3419.6	13	9.78_4
3420.6	14	9.99_4

4377 *T Virginis.*

(Continued from 308)

Julian	Calendar	Mag.
	1895	
3270	Mar. 17 to	
3370	June 25	13.0]
6 dates		

4407 *R Corvi.*

Julian	Calendar	Mag.
	1895	
3272.6	Mar. 19	12.5
3289.6	Apr. 5	11.8
3295.6	11	11.70_2
3301.6	17	11.48_2
3312.6	28	11.09_2
3325.6	May 11	9.36_3
3326.6	12	8.87_3
3327.5	13	9.10_2
3329.5	15	8.28_2
3332.5	18	8.98_2
3337.6	23	8.57_2
3343.6	29	7.85_3
3346.6	June 1	8.22_2
3352.6	7	7.41_2
3359.6	14	7.36_2
3362.6	17	7.70_2
3364.6	19	7.69_2
3365.6	June 20	7.79_2
3370.6	25	7.93_2

4596 *U Virginis.*

(Continued from 326)

Julian	Calendar	Mag.
	1895	
3270.6	Mar. 17	9.7
3289.6	Apr. 5	9.0
3295.5	11	8.64_2
3302.6	18	7.73_2
3316.5	May 2	7.10_2
3325.5	11	7.83_2
3337.6	23	7.85_2
3343.6	29	8.03_2

4847 *S Virginis.*

(Continued from 326)

Julian	Calendar	Mag.
	1895	
3272.6	Mar. 19	9.7
3289.6	Apr. 5	8.8
3301.6	17	8.28_2
3316.6	May 2	6.04_2
3317.5	3	6.3
3318.5	4	6.38_2
3321.6	7	6.22_3
3327.6	13	5.47_2
3329.6	15	6.20_2
3337.6	23	6.65_2
3343.6	29	5.93_2
3346.6	June 1	5.92_2

5037 *RR Virginis*

(Continued from 308)

Julian	Calendar	Mag.
	1895	
3301.6	Apr. 17	13.4 :
3307.6	23	13.4
3325.6	May 11	11.6
3327.6	13	11.83_2
3329.6	15	11.90_2
3337.6	23	11.71_2
3342.6	28	12.11_2
3359.6	June 14	12.2
3361.6	16	12.08_2
3368.6	23	12.29

5070 *Z Virginis.*

(Continued from 308)

Julian	Calendar	Mag.
	1895	
3301.6	Apr. 17	13.0]
3307.6	23	13.0 :
3325.6	May 11	13.0]
3337.6	23	13.0]
3359.6	June 14	11.0
3360.6	15	10.89_2
3365.6	20	10.95_2
3385.6	July 10	10.06_2
3387.6	12	10.30_2
3394.6	19	10.37_2
3403.6	28	10.6

5144 *Y Bootis.*

(Continued from 329)

Julian	Calendar	Mag.
	1895	
3258.608	Mar. 5	8.59_2
.610		8.67_2
.613		8.62_3
.617		8.65_3
.621		8.22_3
.635		8.29_4
.640		8.01_5
.644		8.06_4
3271.577	Mar. 18	8.00_2
.581		8.15_2
.585		8.14_2
.589		8.11_2
.616		8.18_2
.620		8.09_2
.623		7.94
.625		8.71
.627		8.84
.629		8.72
.637		7.90_2
.641		8.08_2
.645		8.19_2
.649		8.17_2
3284.540	Mar. 31	7.74_2
.546		6.75
.549		8.60
.568		7.54_3
.576		7.61_2
.580		7.73_2
3323.543	May 9	7.14_3
.550		6.97_4
.557		7.21_8
.570		7.09_3
.575		8.03_2
.580		7.87_3
.585		7.44_2
.592		7.92_4
.599		8.01_3
.605		8.20_8
.611		8.47
.616		7.87_4
.625		8.09_5
.638		8.01_5
.647		8.05_5
.655		8.13_5
.671		7.39_2
.681		6.60_6
3344.586	May 30	7.22_5
.592		7.15_3
.597		7.72
.600		7.23
.603		7.01
.609		6.84_3
.615		6.83_3
.621		6.95_3
3443.503	Sept. 6	7.79_5
.514		7.96_5
.525		7.79_5
.536		7.79_5
.547		7.97_5
.558		7.74_5
.569		7.96_5

5174 *RS Virginis.*

Julian	Calendar	Mag.
	1894-5	
2988	June 8	11
3000	20	12
3007	27	12
3289.6	Apr. 5	8.6
3302.6	18	8.76_2
3316.6	May 2	9.15_2
3318.6	4	8.56_2
3321.6	7	8.90_2
3327.6	13	9.30_2
3343.6	29	10.24_2
3362.6	June 17	10.19_2
3419.6	Aug. 13	11.8

5194 *V Bootis.*

(Continued from 333)

Julian	Calendar	Mag.
	1895	
3307.6	Apr. 23	8.16_2
3318.6	May 4	9.30_2
3329.6	15	7.97_2
3343.6	29	8.60_2
3352.6	June 7	8.66_2
3365.6	20	8.87_2
3377.6	July 2	9.31_2
3385.6	10	9.37_2
3401.6	26	9.37_2
3414.6	Aug. 8	9.57_2
3423.5	17	9.36_2
3434.6	28	9.29_2
3445.5	Sept. 8	9.21_2

5237 *R Bootis.*

(Continued from 333)

Julian	Calendar	Mag.
	1895	
3271.6	Mar. 18	8.6
3364.6	June 19	11.4
3370.6	25	11.41
3418.6	Aug. 12	8.90_2
3428.6	22	9.09_2
3434.6	28	8.47_2
3442.5	Sept. 5	7.80_2
3448.5	11	7.67_2
3455.5	18	7.05_2
3459.5	22	7.11_2
3460.5	23	7.17_2
3464.5	27	8.02_2
3465.5	28	7.79_2

5249 *V Librae.*

(Continued from 333)

Julian	Calendar 1895	Mag.
3307	Apr. 23 to	
3368	June 23	13.0]
	5 dates	
3386.6	July 11	13.0 :

5430 *T Librae.*

(Continued from 333)

Julian	Calendar 1895	Mag.
3370	June 25	12]
3419	Aug. 13	12]

5438 *Y Librae.*

(Continued from 333)

Julian	Calendar 1895	Mag.
3307	Apr. 23 to	
3403	July 28	12]
	7 dates	

5438 *Y Librae.*—Cont.

Julian	Calendar 1895	Mag.
3419.6	Aug. 13	10.0
3420.6	14	9.68_2
3428.6	22	8.79_2
3429.5	23	9.14_2
3431.5	25	9.27_2
3441.5	Sept. 4	9.12_2
3452.5	15	9.05_2
3457.5	20	9.1
3459.5	22	9.00_2

5494 *S Librae.*

(Continued from 333)

Julian	Calendar 1895	Mag.
3327.6	May 13	9.1
3329.6	15	9.40_2

5494 *S Librae.*—Cont.

Julian	Calendar 1895	Mag.
3356.6	June 11	8.70_2
3362.6	17	7.90_2
3370.6	25	8.20_2
3382.6	July 7	8.22_2
3387.6	12	8.51_2
3394.6	19	8.58_2

5501 *S Serpentis.*

(Continued from 333)

Julian	Calendar 1895	Mag.
3305.6	Apr. 21	11.3
3327.6	May 13	9.7
3343.6	29	9.08_2
3346.6	June 1	8.28_2
3351.6	6	8.35_2
3360.6	15	8.73_2

5511 *RS Librae.*

(Continued from 333)

Julian	Calendar 1895	Mag.
3330.6	May 16	11.1
3342.6	28	10.9
3362.6	June 17	9.06_2
3387.6	July 12	8.28_2
3391.6	19	7.92_2
3401.6	26	7.86_2
3405.6	30	7.81_2
3408.6	Aug. 2	8.31_2
3411.6	5	8.21_2
3420.6	14	8.61_2

5583 *X Librae.*

(Continued from 333)

Julian	Calendar 1895	Mag.
3330.6	May 16	12.6]
3359.6	June 14	12.4]

5583 *X Librae.*—Cont.

Julian	Calendar 1895	Mag.
3370.6	June 25	11.5
3385.6	July 10	11.3
3419.6	Aug. 13	11.7

5675 *V Coronae.*

(Continued from 333)

Julian	Calendar 1895	Mag.
3307.5	Apr. 23	9.31_2
3327.6	May 13	8.61_2
3343.6	29	8.80_2
3351.6	June 6	8.99_2
3361.6	16	9.09_2
3377.6	July 2	9.31_2

COMPARISON-STARS.

4407 *R Corvi.*

D	−18°3379	7.01	6*M*
1*D*	−18°3380	7.12	4
E	−18°3388	7.66	4
H	−18°3368	8.25	16*M*
1*H*	−18°3393	7.76	4
L	−18°3369	8.72	17*M*
1*L*	−17°3596	9.15	5*M*
R	−18°3382	8.82	5

4407 *R Corvi.*—Cont.

1*T*	−18°3365	10.46	8
1*U*	−18°3373	10.34	5
1*W*	−18°3372	10.74	10
X	−18°3370	11.42	2
Z	−18°3366	11.61	5
1*Z*	−18°3371	12.11	1
i	4*n*1*f* 1*W*	12.15	4
k	2*s* *L*	12.51	1

5174 *RS Virginis.*

F	+4°2878	7.40	3*M*
H	+5°2879	7.35	3
I	+4°2859	7.95	2*M*
1*I*	+4°2879	7.27	3
N	+4°2866	8.61	9*M*
1*N*	+4°2877	8.36	3
2*N*	+4°2864	8.62	7
2*R*	+4°2869	8.85	7

5174 *RS Virginis.*—Cont.

Z	+5°2883	10.33	3
2*Z*	+4°2867	11.84	1
3*Z*	+4°2870	11.21	1
4*Z*	+5°2884	10.04	3
g	4*s*7*f* *H*	11.77	1
l	2*n*4*f* *V*	12.84	1
o	3*n*3*p* *V*	13.46	1

CORRIGENDUM.— Page 106, Comparison-Star *N* is SDM.—14°2897.

ERRATA IN KLINKERFUES'S FORMULAS FOR METEOR-PATHS; AND IN THE VALUE OF LOG ρ FOR THE LICK OBSERVATORY,

By J. M. SCHAEBERLE.

I consider it very desirable to call special attention to some errors in the fundamental formulas published in the treatise "*Ueber die Bahnbestimmung der Meteore, Meteoriten und Sternschnuppen,*" as I have been put to much useless labor in the reduction of some meteor-observations made simultaneously at Mt. Hamilton and Mt. Diablo.

All doubts as to the correctness of KLINKERFUES's formulas seem to disappear when the computer finds that for the example given—the data being taken from actual observations—he obtains by substitution, in the published formulas, the same results as the author.

The errors so far discovered are, according to my derivations, as follows:

1. Page 431. The equation $\odot$), giving the criterion, for determining whether the same meteor was observed at the two stations, is wrong; the algebraic signs of the second and third terms of the first member of the equation must be interchanged.

2. Equation III. The factor $\sin(\alpha-\alpha')$ must be changed to $\sin(\alpha'-\alpha)$.

3. In the last formula given on page 431 (the expression for ρ when the parallactic displacement in right-ascension is small) the *second* term of the *numerator* is wrong; the factor $\sin\delta$ must be changed to $\sin D$.

4. Last line, page 431. The expression for ρ' is not, as KLINKERFUES states, symmetrical with that given for ρ. When solving for ρ' the algebraic signs of the two terms in the *denominator* must be interchanged.

5. All the numerical work on page 435 (so far as it relates to the formulas given on page 431) is wrong: the observations refer to two different meteors.

ON LOG ρ FOR THE LICK OBSERVATORY.

I have found that all the published values of $\log\rho$ as given in the various *Nautical Almanacs* refer to *sea level*, for both the BESSEL and CLARKE spheroids; they are therefore in error by about eight-tenths of a mile, or 874 units of the seventh decimal place of $\log\rho$. The correct values of $\log\rho$ and $\phi-\phi'$ for the Lick Observatory, are according to my computations:

	BESSEL	CLARKE
$\log\rho$	9.999556	9.999548
$\phi-\phi'$	$+11'\ 5''.37$	$+11'\ 14''.80$

Lick Observatory, 1895 *Sept.* 17.

MICROMETRICAL COMPARISONS OF POSITIONS OF *TITAN* AND *RHEA*,

By E. O. LOVETT.

The following observations were made with the twenty-six-inch refractor of the Leander McCormick Observatory. The angles given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction.

1894	Eastern Time	p	Eastern Time	s
	h m s	°	h m s	″
Mar. 1	17 37 20	267.77	17 52 54	125.42
5	16 7 56	270.66	. . .	. .
6	16 49 11	281.61	17 38 13	185.86
	18 5 49	282.70	17 45 43	181.55
8	13 1 26	64.92	14 5 57	117.23
	14 31 14	67.43	. . .	. .
12	17 5 54	88.60	17 33 54	239.03
	17 46 10	88.87	. . .	. .
13	16 53 30	99.64	18 9 54	206.63
	17 56 47	100.24	. . .	. .
14	16 0 8	134.71	17 15 23	71.56
	17 5 47	140.19	17 19 19	72.03
15	12 23 48	232.67	13 22 40	75.98
	13 2 59	233.57	13 25 17	76.31
	13 11 51	234.15	13 28 17	76.31
	13 19 9	234.62	13 31 10	75.27
	13 36 29	235.53	14 18 56	76.42
	14 7 31	236.81	14 21 45	76.87
	15 45 56	238.60	. . .	. .
17	16 30 17	235.45	16 34 53	57.64
	17 14 1	235.28	16 50 0	57.52
18	11 44 40	250.81	11 55 50	130.04
	12 18 8	251.65	12 3 50	130.50
	15 7 20	253.76	15 13 33	148.38
	15 20 45	254.18	15 16 20	148.81
21	16 34 58	290.80	16 40 54	109.86
	16 52 41	291.03	16 46 24	109.56
	17 33 34	291.79	16 48 54	109.41
22	16 14 26	311.43	. . .	. .
23	15 24 40	290.76	16 49 46	64.96
	16 26 41	290.96	16 52 27	64.98
	17 4 32	291.25	16 56 22	64.93
	. . .	. .	16 59 34	64.84
26	14 35 28	82.37	16 14 12	251.18
	16 2 2	83.18	16 20 33	250.90
30	14 25 58	98.54	15 14 11	131.69
	15 5 13	98.35	15 18 17	132.02
Apr. 2	15 56 31	260.69	16 6 47	221.99
	16 24 27	260.88	16 15 14	221.24
4	12 46 29	269.34	12 43 49	123.52
	. . .	. .	13 1 13	124.40
8	15 49 59	22.83	15 55 37	62.00
	16 5 51	23.21	15 59 16	61.91
15	11 16 12	145.39	11 19 57	61.01
	11 33 45	146.74	11 22 59	61.14
	13 50 11	160.31	11 26 15	60.56
	14 3 9	161.05	11 28 50	60.54
	14 13 11	162.23	13 55 12	53.05
	14 28 14	162.30	13 57 12	52.79
	. . .	. .	14 6 24	52.57
	. . .	. .	14 8 41	52.53
Apr. 17	12 40 38	237.13	12 44 54	41.86
	12 50 57	237.09	12 47 5	41.70
	13 2 22	237.19	12 54 19	41.86
	. . .	. .	12 56 28	41.51
24	13 45 58	286.78	13 49 31	84.40
	13 55 30	286.82	13 52 48	84.27
25	11 58 50	330.48	12 2 29	52.90
	12 7 12	331.23	12 4 19	52.76
	14 59 18	349.00	15 7 12	49.17
	15 13 17	350.90	15 9 35	49.08
26	12 57 12	71.39	13 1 16	158.95
	13 10 20	71.50	13 4 52	158.97
27	15 46 56	266.96	15 52 19	250.83
	16 2 30	266.31	15 57 40	251.44
29	8 48 52	98.36	8 52 8	105.38
	8 56 45	98.53	8 54 17	105.45
	9 56 17	98.55	10 0 2	102.37
	10 7 10	98.32	10 2 59	102.32
May 1	11 43 13	98.34	11 46 0	147.81
	11 53 8	98.76	11 48 13	147.69
	14 46 1	99.87	14 51 39	146.69
	14 57 27	99.73	14 55 31	146.97
2	11 46 7	129.14	11 49 23	79.76
	11 53 12	129.77	11 51 31	79.79
	13 0 17	133.54	13 6 1	74.36
	13 12 26	134.37	13 8 42	74.37
3	12 22 7	246.47	12 25 8	135.90
	12 30 42	246.37	12 27 2	135.81
9	14 3 38	292.48	14 6 25	123.52
	14 11 10	292.71	14 8 49	123.50
10	13 18 56	48.01	13 22 7	73.03
	13 26 51	49.64	13 24 23	73.11
12	9 34 21	78.53	9 37 21	81.72
	9 43 14	78.68	9 40 57	81.74
13	12 5 26	74.48	12 7 54	91.35
	12 12 9	74.54	12 9 41	91.31
	13 8 27	74.78	13 12 53	99.58
	13 21 16	74.69	13 16 31	99.73
16	11 41 20	104.84	11 43 59	149.97
	11 48 51	105.06	11 46 21	150.13
17	12 15 43	194.79	12 18 43	41.93
	12 21 25	195.40	12 21 22	41.99
	13 39 41	202.51	13 44 35	43.19
	13 48 25	202.90	13 46 34	43.09
21	9 46 41	259.63	9 49 43	214.00
	9 55 48	259.75	9 52 35	215.50
24	11 24 5	289.75	11 26 36	68.00
	11 30 29	289.97	11 28 36	67.98
	12 10 41	289.77	12 16 6	66.65
	12 19 43	289.61	12 17 45	66.60
28	12 37 26	77.72	12 42 53	196.20
	12 47 36	77.44	12 43 59	195.80
June 2	9 18 12	99.36	9 22 17	150.99
	9 26 7	99.60	9 24 26	151.00
	12 59 22	102.21	13 2 47	143.90
	13 5 47	102.15	13 4 15	143.84
7	10 29 37	264.21	10 31 24	123.60
	10 35 7	264.01	10 33 19	123.45

1894	Eastern Time	p	Eastern Time	s	1894	Eastern Time	p	Eastern Time	s
	h m s	°	h m s	″		h m s	°	h m s	″
June 7	12 8 42	263.90	12 10 49	128.46	June 15	12 36 31	85.70	. . .	. .
	12 15 47	263.70	12 13 11	128.46	24	10 32 11	279.76	10 35 16	127.84
10	9 48 38	298.08	9 52 18	97.42		10 39 6	279.82	10 36 10	128.05
	9 57 48	298.03	9 54 21	97.49	July 8	10 1 46	264.05	10 4 10	97.58
11	9 58 50	57.42	10 2 3	75.69		10 9 43	264.18	10 6 30	97.28
	10 5 45	57.64	10 2 56	75.90					

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1895 (SWIFT),

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY ORMOND STONE.

1895 Charlottesville M.T.		∗	No. Comp.	☄ — ∗		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Sept. 15	15 22 19	1	6	−5 51.18	. . .	1 13 43.63	. . .	9.352	. .
	16 17 56	1	2	. . .	+5 3.3	. . .	+5 48 15.5	. .	0.685
17	13 42 19	2	17	+1 15.62	. . .	1 15 36.47	. . .	8.468	. .
	13 56 11	2	2	. . .	+2 15.9	. . .	+5 39 17.9	. .	0.671
18	11 6 54	2	2	. . .	−1 15.2	. . .	+5 35 46.8	. .	0.682
	11 29 52	2	16	+2 4.78	. . .	1 16 25.65	. . .	n9.350	. .
	11 46 2	3	16	−1 42.62	. . .	1 16 26.12	. . .	n9.289	. .
	12 14 37	3	4	. . .	+0 7.6	. . .	+5 35 39.7	. .	0.674
19	14 9 51	3	20	−0 48.02	. . .	1 17 20.73	. . .	8.988	. .
	14 28 6	3	3	. . .	−4 28.8	. . .	+5 31 3.3	. .	0.675
20	13 35 18	4	2	. . .	+0 12.4	. . .	+5 26 52.0	. .	0.673
	14 7 27	4	9	−5 19.20	. . .	1 18 8.10	. . .	8.994	. .
21	11 58 13	5	4	. . .	−0 40.1	. . .	+5 22 39.4	. .	0.676
	12 15 31	5	24	−1 48.99	. . .	1 18 49.49	. . .	9.080	. .
22	13 45 20	5	12 , 4	−1 5.12	−5 27.2	1 19 33.38	+5 17 52.3	8.827	0.675
27	16 2 36	6	12 , 4	+0 14.83	−3 38.9	1 22 23.90	+4 54 5.6	9.570	0.696
30	16 21 54	7	1	. . .	−1 13.9	. . .	+4 39 54.2	. .	0.703
	16 32 8	8	1	. . .	+0 36.0	. . .	+4 39 53.3	. .	0.705
	16 46 54	7 , 8	5	+4 42.33	. . .	1 23 37.84	. . .	9.607	. .

Mean Places for 1895.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 19 31.20	+3.61	+5 42 46.5	+25.7	Bessel, Zone 116
2	1 14 17.21	+3.64 +3.66	+5 36 36.1	+25.9 +25.9	⅓(Foerster + Kam + Argelander), *A.N.* 1328, 1464, 1482
3	1 18 5.09	+3.65	+5 35 6.1	+26.0	Filar-micrometer comparison with ∗ 2
4	1 23 23.64	+3.66	+5 26 13.5	+26.1	Foerster, *Astr. Nachr.*, no. 1327
5	1 20 34.80	+3.68 +3.70	+5 22 53.3	+26.2 +26.2	Filar-micrometer comparison with ∗ 4
6	1 22 5.28	+3.79	+4 57 17.8	+26.7	Boss 402, *Astr. Gesell. Catal.* (Albany)
7	1 18 40.24	+3.83	+4 40 41.1	+27.0	Boss 385, *Astr. Gesell. Catal.* (Albany)
8	1 19 3.13	+3.83	+4 38 50.3	+27.0	Boss 387, *Astr. Gesell. Catal.* (Albany)

The comet has a very faint stellar nucleus (15½ mag.), which was nearly always readily distinguished.
Sept. 30. Extremely faint in twilight.

NOTE ON THE SOLAR PARALLAX, AS DERIVED FROM THE OBSERVED PARALLACTIC INEQUALITY OF THE MOON,

BY S. NEWCOMB.

In deriving the solar parallax from the parallactic inequality, we necessarily assume the relation between these quantities to be accurately given by theory. In my work on this subject I have used the relation as determined by the aid of HANSEN's numerical theory. The comparison of this theory with that of DELAUNAY, given in the first volume of the Astronomical Papers of the American Ephemeris, tends to inspire confidence in the precision of his results, because, where the coefficients were well determined from DELAUNAY's theory, the agreement was very generally satisfactory; and where DELAUNAY's terms were not well determined, owing to the defective convergence of the series, the difference was generally quite compatible with the probable value of the terms omitted by DELAUNAY.

In the case of the parallactic inequality, however, the agreement could be brought about only by assuming either a somewhat improbable irregularity in the progression of the higher terms omitted by DELAUNAY, or an error in the highest term which he computed. As the doubtful term in question was incompatible with the seeming law of the series as derived inductively from the preceding terms, while this law, if accepted throughout, would reproduce HANSEN's result, I accepted the latter with entire confidence in its correctness.

Now, however, the results published by Mr. G. W. HILL in No. 353 of the *Astronomical Journal*, taken in connection with the previous results of Professor BROWN, given in the *American Journal of Mathematics*, Vol. XIV, confirm DELAUNAY's theory, so far as the principal doubtful term is concerned. Accepting this confirmation, and deriving the values of those terms which depend on the eccentricity and inclination by DELAUNAY's theory, as conjecturally completed through induction, the result will be an increase of the Hansenian theoretical value corresponding to a given value of the solar parallax by 0″.30. Conversely, the value of the solar parallax derivable from the observed value of the parallactic inequality should be diminished by 0″.021. I have found for the value in question, from HANSEN's theory, 8″.794. If, then, we accept the conclusions here reached, we shall have

Solar parallax from parallactic inequality = 8″.773.

We cannot, however, regard this correction as conclusive, because there is still some doubt as to the theoretical magnitude of the terms in e^2 and γ^2, owing to the incompleteness of DELAUNAY's theory. The uncertainty would, however, be less than 0″.10 in each term, and therefore less than 0″.01 in the solar parallax, were it not that the case of the principal term shows that the process of completing the series of the lunar theory by induction is always a doubtful one. The determination of the quantities depending on the lunar eccentricity and inclination by the new methods of HILL and BROWN are therefore much to be desired.

NEW ASTRONOMICAL WORKS.

Erd-und Himmelsgloben, Ihre Geschichte und Konstruction. Nach dem Italienischen MATTEO FIORINIS *frei gearbeitet* von SIEGMUND GÜNTHER. Leipzig, B. G. Teubner, 1895.

An elaborate treatise on the history and construction of terrestrial and celestial globes. It has been expanded by the translator into nearly twice the volume of the original; and the present work seems likely to remain, for some time, the chief authority on its subject.

Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac.

Vol. V, part III, of this series contains the 'Theory of the Inequalities in the Motion of the Moon, produced by the Action of the Planets,' by Prof. SIMON NEWCOMB. It is a treatise of 195 pages;—chapter I consisting of a discussion of the General Theory of the motion of three bodies; chapter II, of the application of the same to the special case of the moon's motion; and chapter III giving the numerical developments for determining the action of the several planets on the moon,—*Mercury*, *Venus*, *Mars and Jupiter* being considered.

Vol. V, part IV, 78 pages, is a discussion, by Prof. NEWCOMB, of the secular variations of the orbits of the four inner planets, and gives the final results for the three fundamental epochs, 1600, 1850, and 2100.

Vol. VII, part I, comprises the Tables of *Jupiter* by Prof. GEORGE W. HILL.

J. M. SCHAEBERLE. *Report on the Total Eclipse of the Sun, observed at Mina Bronces, Chile, on April 16, 1893.*

This contains in the first place, a narrative of the expedition, with a description of the instruments, and accounts of the voyages outward and homeward, the place selected for the station, and of the routine adopted in obtaining the photographs. Eight of these were taken by Prof. SCHAEBERLE, with a Clark lens of 40 feet focus and 5 inches aperture: ten by Messrs. GALE and WALKER with a Clark equatorial of 6 feet focus; ten by Messrs. KING and BRAY with a 6-inch Dallmeyer portrait lens; six by Mr. TIREPEGUI with a 5×7-inch camera, and eighteen by Mr. HOLE with a 4×5-inch camera.

The results comprise a detailed description of the prominences, coronal arches and streamers shown on the plates; as well as positions of the comet detected by Prof. SCHAEBERLE in the photographs, and a summary of his mechanical theory of the Corona, which have already been published.

The Report is abundantly illustrated, and numerous photographs are given.

CORRIGENDUM.

No. 355, p. 157, line 21, *for* (7084) *read* (6871).

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed October* 12.

THE

ASTRONOMICAL JOURNAL.

No. 357.

VOL. XV. BOSTON, 1895 OCTOBER 29. NO. 21

RESEARCHES ON THE ORBIT OF ζ *HERCULIS* = Σ2084,

By T. J. J. SEE.

This celebrated double star was discovered by Sir **William Herschel** July 18, 1782. On July 21 he measured the position of the companion, and obtained an angle of 69°.3. In 1795 **Herschel** again examined the object, and noted that the distance had decreased, but that it was in the same quadrant as before; this appears, however, to be a mistake, as the companion at that time must have been in the opposite quadrant. It is remarkable that **Herschel** could not separate the companion in 1802, as the angle was then 174°.5, and the distance 1″.24.

Beginning with **Struve**'s observation in 1826 the record is practically continuous, and we have measures for each year, except when the companion was so close as to be lost in the rays of the larger star.

The periastron is so near the central star, on account of the considerable eccentricity and the position of the node, that the companion has never been seen in this part of the orbit. According to the elements found below, the minimum distance is about 0″.45. Therefore, in spite of the comparative faintness of the companion, whose magnitude is 6.5, while that of the central star is 3.0, this object ought to be constantly within the reach of our great refractors. In previous revolutions, however, the star has been lost, and it will therefore be a matter of great interest to follow it during the next periastron passage in 1899. Good observations in this part of the orbit are needed, and the rare phenomenon which will be presented by ζ *Herculis* about the end of this century will be worthy of the attention of observers with large telescopes.

Notwithstanding the three revolutions which have been completed since **Herschel**'s discovery in 1782, our knowledge of the orbit of this pair has remained somewhat unsatisfactory; the elements heretofore obtained are by no means accordant. This divergency of results may be attributed partly to errors of observation incident to the inequality of the components, and partly to a sensible mistake in the old position-angle of **Herschel**, which ought to have been about 80°. Indeed, **Herschel**'s observation does not seem to lay claim to much accuracy, for on August 30, 1782, he says: "Saw it better than I ever did,"—implying that on the previous occasions the companion was not very well defined. The following table gives the elements published by previous investigators:

P	T	e	a	Ω	i	λ	Authority		Source
			″	°	°	°			
30.216	1830.42	0.432	1.208	19.4	44.1	276.65	Mädler,	1847	
31.4678	1829.50	0.4545	1.189	39.43	50.9	262.1	Mädler.		A.N., vol. XVI, p. 33–42
36.357	1830.481	0.4482	–	214.35	43.7	284.9	Villarceau,		A.N., vol. XXVI, p. 305
36.715	1830.237	0.4831	1.350	41.9	49.1	290.6	Villarceau,	1854	C.R., XXXVIII, p. 871
37.21	1830.56	0.4381	–	37.23	39.35	266.9	Fletcher,	1853	M.N., XIII, p. 258
34.221	1830.01	0.4239	1.223	45.93	34.87	209.5	Dunér,	1871	A.N., 1868
36.606	1829.635	0.5511	1.374	27.0	50.23	266.7	Plummer.	1871	M.N., XXXI, 195
34.58	1864.90	0.405	1.36	26.13	51.11	260.97	Flammarion,	1874	Catalogue Ét. Doub., p. 101
34.4	1864.8	0.463	1.284	41.73	43.23	252.75	Doberck.	1880	A.N., 2332
34.411	1864.78	0.4666	1.345	44.1	44.53	251.8	Doberck.		

After an examination of all the observations I formed mean positions for each year, and from these mean places deduced the following elements:

$$P = 35.00 \text{ years}$$
$$T = 1864.80$$
$$e = 0.497$$
$$a = 1''.4321$$
$$\Omega = 37^\circ.5$$
$$i = 51^\circ.77$$
$$\lambda = 101^\circ.7$$
$$n = -10^\circ.2843$$

Apparent orbit:

Length of major axis = 2″.492
Length of minor axis = 1″.752
Angle of major axis = 43°.1
Angle of periastron = 289°.0
Distance of star from center = 0″.455

The following table of computed and observed places shows that the elements give a good representation of the observations, and render it probable that the present orbit is very near the truth. There are some errors in the position-angles which appear to be systematic, and we have not been able to improve the representation; for whatever would improve the agreement in one place would injure it in another, or in the same place during the next revolution.

It will be seen that this orbit is slightly more eccentric than most of those heretofore deduced, but it is not probable that the eccentricity will prove to be too large. If any change should be required in this element, it is likely to increase rather than diminish the value given above. The eccentricity of the orbit of *ζ Herculis* is near the mean value of this element among double stars, and is such that solutions of Kepler's equation by the methods heretofore in use are slow and tedious. Therefore it does not appear inappropriate to call the attention of astronomers interested in solutions of Kepler's equation for the more eccentric orbits to the rapid and extremely practical method which I have discussed in the paper communicated to the Royal Astronomical Society at the June meeting. The possibility of this method was long ago made known by Du Bois, but it does not appear to have come into actual use. The method is general for ellipses of all possible eccentricities, and in the theory of double stars and periodic comets will prove to be of the greatest service.

Comparison of Computed with Observed Places.

t	θ	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
		°	″	″	°	″		
1782.55	69.3	80.5	–	1.51	−11.2	–	1	Herschel
1795.80	–	248.9	–	0.65	–	–	1	Herschel
1802.71	–	174.5	–	1.24	–	–	1	Herschel
1826.63	23.4	27.1	0.91	1.00	− 3.7	−0.09	5	Struve
1828.71	349.5	344.0	0.65	0.54	+ 5.5	+0.11	1	Struve
1832.72	220.5	216.0	0.81	0.97	+ 1.5	−0.16	1	Struve
1834.45	203.5	201.5	0.91	1.11	+ 2.0	−0.23	2	Struve
1835.45	196.9	191.6	1.09	1.20	+ 5.3	−0.11	5	Struve
1836.60	186.2	182.8	1.09	1.23	+ 3.4	−0.14	5	Struve
1838.70	168.5	167.5	1.35	1.24	+ 1.0	+0.11	3 ±	Galle
1839.76	161.9	159.9	1.22	1.25	+ 2.0	−0.03	4	Dawes
1840.66	157.1	153.7	1.25	1.25	+ 3.4	±0.00	5	O. Struve
1841.56	146.4	147.2	1.24	1.25	− 0.8	−0.01	16–6	Mädler, 9–0; *OΣ*., 3; Dawes, 4–3
1842.54	142.0	140.3	1.14	1.26	+ 1.7	−0.12	9–4	Mädler, 3–0; Dawes, 3–1; *OΣ*., 3
1843.65	130.1	132.1	1.30	1.28	− 2.0	+0.02	20–2	Mädler, 8–0; Dawes, 3–2; Mädler, 9–0
1844.50	124.7	127.1	1.12	1.30	− 2.4	−0.18	7–2	Mädler, 5–0; *OΣ*., 2
1845.64	121.3	119.3	1.24	1.32	+ 2.0	−0.08	3	O. Struve
1846.79	111.3	112.1	1.31	1.35	− 0.8	−0.04	7–2	*OΣ*., 2; Dawes, 5–0
1847.55	107.9	107.4	1.43	1.38	+ 0.5	+0.05	21–20	Mädler, 18–17; Dawes, 1; *OΣ*., 2
1848.59	101.8	101.4	1.52	1.41	+ 0.4	+0.11	8–5	Mädler, 3–0; Dawes, 3; *OΣ*., 2
1849.48	99.2	96.5	1.71	1.44	+ 2.7	+0.27	1	Dawes
1850.36	93.3	91.7	1.39	1.46	+ 1.6	−0.07	8–6	*OΣ*., 3; Fletcher, 2; Mädler, 3–1
1851.50	87.9	85.7	1.35	1.49	+ 2.2	−0.14	16–14	Mädler, 3; Fletcher, 6; *OΣ*., 5; Miller, 2–0
1852.67	83.8	79.8	1.32	1.52	+ 4.0	−0.20	20–14	*OΣ*., 5; Mädler, 8–7; Fletcher, 5–2; Miller, 2–0
1853.46	78.3	76.1	1.38	1.53	+ 2.2	−0.15	23–20	Jacob, 2; Miller, 6–3; Mädler, 8; *OΣ*., 4; Mädler, 3
1854.46	75.0	71.2	1.47	1.53	+ 3.8	−0.06	11	Jacob, 3; *OΣ*., 3; Mädler, 5
1855.46	70.8	66.4	1.47	1.53	+ 4.4	−0.06	21–11	Dembowski, 13–0; Secchi, 3; *OΣ*., 4; Morton, 1
1856.48	64.8	62.2	1.43	1.51	+ 2.6	−0.08	27	Jacob, 3; Dembowski, 15; Secchi, 6; *OΣ*., 3
1857.61	59.0	55.5	1.35	1.46	+ 3.5	−0.11	24	Mädler, 4; Mo., 2; Secchi, 6; *OΣ*., 4; Dem., 5; Ja., 3
1858.58	51.0	50.5	1.19	1.40	+ 0.5	−0.21	22–21	Secchi, 2; Dembowski, 8; *OΣ*., 4; Mädler, 8–7
1859.58	43.1	44.1	1.25	1.30	− 1.0	−0.05	19–15	Mädler, 6; Secchi, 3–0; Dawes, 6–5; *OΣ*., 4
1860.70	32.0	36.5	1.05	1.16	− 4.5	−0.11	4	Secchi, 3; *OΣ*., 1
1861.50	18.6	28.5	0.93	1.02	− 9.9	−0.09	6	Mädler, 2; *OΣ*., 4
1862.73	11.2	12.9	1.00	0.78	− 1.7	+0.22	9–1	Dembowski, 8; *OΣ*., 1; Mädler, 2
1863.49	343.0	352.2	cuneo	0.59	− 9.2	–	4	Dembowski
1865.55	250.0	256.6	<0.5	0.59	− 6.6	−0.09	3	Engelmann
1866.74	232.5	229.0	0.85	0.85	+ 3.5	±0.00	14	Dembowski, 5; Dawes, 3; *OΣ*., 2; Dawes, 2; Dawes, 2

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
	°	°	″	″	°	″		
1867.62	223.5	217.2	0.91	0.99	+ 6.3	−0.08	9	Dembowski, 7; Dunér, 2
1868.54	208.3	207.7	1.05	1.09	+ 0.6	−0.04	17	Dembowski, 6; Knott, 4; *OΣ*., 2; Dunér, 5
1869.60	201.8	198.2	1.08	1.16	+ 3.6	−0.08	19	Dembowski, 8; Dunér, 11
1870.54	192.0	190.9	1.15	1.20	+ 1.1	−0.05	17	Dembowski, 11; Dunér, 6
1871.52	181.9	183.5	1.21	1.23	− 1.6	−0.02	32	Dembowski, 11; *OΣ*., 1; Knott, 5; Dunér, 12
1872.55	173.3	176.0	1.22	1.24	− 2.7	−0.02	27	Dembowski, 12; Dunér, 12; *OΣ*., 3
1873.60	166.1	168.3	1.22	1.24	− 2.2	−0.02	17	Dembowski, 11; *OΣ*., 2; Dunér, 1
1874.60	160.0	161.1	1.37	1.24	− 1.1	+0.13	14–15	Dembowski, 10; *OΣ*., 4; Dunér, 0–1
1875.56	148.5	151.5	1.30	1.25	− 6.0	+0.05	29–27	Dembowski, 8; Schiaparelli, 7; W. & S., 2–0; Dunér, 12
1876.56	141.0	148.6	1.30	1.25	− 7.6	+0.05	10	Hall, 2; Dembowski, 7; Plummer, 1
1877.57	136.3	140.1	1.40	1.26	− 3.8	+0.14	11	Dembowski, 8; Pritchett, 1; Hall, 2
1878.51	126.9	133.6	1.40	1.28	− 6.7	+0.12	10–13	*β*., 1; Schiaparelli, 4; Doberck, 2–1; Dembowski, 7
1879.54	122.5	126.6	1.47	1.30	− 4.1	+0.17	8–16	*β*., 3; Hall, 4; Schiaparelli, 0–8; Pritchett, 1
1880.49	115.8	120.4	1.34	1.32	− 4.8	+0.02	10–15	Doberck, 2–1; Big., 3–0; *β*., 5; Schiaparelli, 0–9
1881.49	110.6	113.9	1.45	1.35	− 3.3	+0.10	17	Doberck, 2; *β*., 5; Hough, 4; Hall, 5; Big., 1
1882.60	105.6	107.2	1.46	1.38	− 1.6	+0.08	17–19	Doberck, 2–0; Hall, 5; Sch., 0–11; Jed., 1–3; En., 6–0
1883.60	101.5	101.3	1.54	1.41	+ 0.2	+0.13	14–29	Per., 4; Hall, 5; Schiaparelli, 0–15; Engelmann, 5
1884.58	94.1	96.6	1.51	1.44	− 2.5	+0.07	28–17	Big., 2–0; Hl., 4; Per., 3; Prit., 1; Sch., 9; Sea., 6–0; En., 3–0
1885.58	89.8	90.5	1.57	1.47	− 0.7	+0.10	29–22	Per., 6; Tar., 4–0; Hall, 7; Sch., 5; Jed., 4; Sea., 3–0
1886.63	87.0	85.0	1.54	1.50	+ 2.0	+0.04	35–32	Hall, 6; Per., 1; Sea., 3–0; Sch., 9; Jed., 9–7; En., 7
1887.60	81.5	80.2	1.57	1.52	+ 1.3	+0.05	24	Hall, 6; Schiaparelli, 18
1888.58	76.1	76.6	1.54	1.53	− 0.5	+0.01	21–14	Hall, 6; Comstock, 3–0; Schiaparelli, 9–8; Maw, 3–0
1889.56	72.7	70.6	1.55	1.54	+ 2.1	+0.01	18–17	Schiaparelli, 3; Glas., 2–1; Hall, 6; Com., 4; Maw, 3
1890.60	66.8	65.6	1.53	1.53	+ 0.2	±0.00	16–15	Glas., 2; Hall, 6; Maw, 3; Schiaparelli, 5–4
1891.57	62.2	60.9	1.43	1.50	+ 1.3	−0.07	23–20	Hall, 6; See, 7–4; Schiaparelli, 2; Big., 5; Maw, 3
1892.60	55.3	55.5	1.44	1.46	− 0.2	−0.02	13	Comstock, 5; Schiaparelli, 8
1893.74	47.6	48.2	1.34	1.37	− 0.6	−0.03	8–7	Schiaparelli, 3–2; Big., 5
1894.58	42.1	44.1	1.20	1.31	− 2.0	−0.11	7–19	Bar., 3; Glas., 2–0; Lewis, 2; Big., 0–14
1895.32	36.7	38.8	1.17	1.21	− 2.1	−0.04	3	See

In order that astronomers may be able to compare the present theory with observations during the rapid motion of the companion in passing periastron, we give an ephemeris for the next ten years:

t	θ_c	ρ_c
	°	″
1896.50	28.5	1.02
1897.50	15.5	0.82
1898.50	351.9	0.56
1899.50	289.7	0.47
1900.50	258.4	0.58
1901.50	233.0	0.80
1902.50	218.4	0.97
1903.50	207.8	1.09
1904.50	198.9	1.16
1905.50	191.0	1.20

The companion is worthy of regular attention in the part of the orbit now being described, but observation will become more urgent as the star approaches periastron in 1899. If good observations can be secured they will enable us to give the highest precision to the theory of the motion of this star; but if the measures in so delicate a case are affected by sensible systematic errors, they will prove to be of little value. The phenomena of the approaching appulse of *ζ Herculis* will therefore be difficult to observe, and results of importance can only be obtained by skillful treatment. It is hardly necessary to add that this phenomenon will not again be witnessed for more than a third of a century.

It seems worthy of remark that STRUVE, who devoted so much attention to the colors of double stars, noted the color of the companion as reddish, while it is now distinctly bluish, and although a change of color does not seem probable, this has been suspected as well as variability.

The University of Chicago, 1895 *Aug.* 22.

RESEARCHES ON THE ORBIT OF *β DELPHINI* = *β* 151.

By T. J. J. SEE.

This rapidly revolving binary was discovered by Professor BURNHAM with his celebrated six-inch Clark Refractor, in August, 1873. The companion was then near its maximum elongation, and was easily measured by DEMBOWSKI in 1874. The measures of the next few years showed that the pair had a rapid direct motion. In 1879–80 the distance of the components became so small (about 0″.20) that the object could be elongated only by the most powerful telescopes. The measures at this time are therefore few in number, and necessarily of doubtful accuracy.

Since the epoch of Dembowski's measures in 1874, the radius-vector of the companion has swept over 335 degrees of position-angle, and the intervening observations enable us to determine the orbit with a comparatively high degree of precision. The following table gives the orbits hitherto published for this star:

P	T	e	a	Ω	i	λ	Authority	Source
			″	°	°	°		
26.07	1882.19	0.357	0.55	163.6	54.9	354.6	Dubiago, 1884	A.N. 2602
30.91	1882.25	0.337	0.517	2.67	59.33	327.8	Gore, 1885	Proc. R.I.A., IV; no. 5
16.95	1885.80	0.096	0.460	10.9	61.6	220.9	Celoria, 1888	A.N., 2824
22.97	1882.37	0.260	0.501	174.2	64.1	343.9	Glasenapp, 1893	A.N., 3177
24.16	1882.38	0.284	0.51	174.4	64.64	344.2	Glasenapp, 1893	A.N., 3177

From an investigation of all the observations we find the following elements for β *Delphini*:

$P = 27.66$ years
$T = 1883.05$
$e = 0.373$
$a = 0''.6724$
$\Omega = 3^\circ.9$
$i = 61^\circ.35$
$\lambda = 164^\circ.93$
$n = +13^\circ.015$

Apparent orbit:

Length of major axis = 1″.060
Length of minor axis = 0″.477
Angle of major axis = 2°.5
Angle of periastron = 176°.6
Distance of star from center = 0″.191

The accompanying table of computed and observed places shows that these elements are extremely satisfactory. The only large residual is that of 1880, which is probably due to an error of observation incident to the excessive closeness of the components.

Comparison of Computed with Observed Places.

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o - \theta_c$	$\rho_o - \rho_c$	n	Observers
		°	″	″	°	″		
1874.66	15.5	15.2	0.65	0.62	+ 0.3	+0.03	5	Dembowski
1875.65	20.1	20.0	0.54	0.55	+ 0.1	−0.01	4	Dembowski
1876.65	25.8	26.2	0.48	0.48	− 0.4	±0.00	4	Dembowski
1877.75	35.3	36.2	0.41	0.38	− 0.9	+0.03	7	Dembowski, 5; Burnham, 2
1878.70	56.4	50.1	0.24	0.29	+ 6.3	−0.05	5–4	β., 4; Dembowski, 1–0
1879.56	90 ±	71.3	Elong. doubtful	0.23	–	–	2	Burnham
1880.68	133.6	114.7	0.26	0.20	+18.9	+0.06	3	Burnham
1881.54	149.2	145.6	0.26	0.24	+ 3.6	+0.02	5	Burnham
1882.60	167.5	169.1	0.26	0.31	− 1.6	−0.05	3	Burnham
1883.40	183.2	181.7	0.21	0.33	+ 1.5	−0.12	10	Engelmann, 7; β., 3
1884.72	197.6	201.2	0.31	0.33	− 3.6	−0.02	12	Hall, 3; Engelmann, 4; β., 5
1885.95	219.8	220.7	0.39	0.28	− 0.9	+0.11	9	Engelmann, 8; H. Struve, 1
1886.86	248.0	247.4	0.30	0.24	+ 0.6	+0.06	8–11	Schiaparelli, 7; Engelmann, 0–4; H. Struve, 1–0
1887.70	275.2	271.8	0.31	0.24	+ 3.4	+0.07	18–19	Tar., 5; Hough, 1; Schiaparelli, 8; H. Struve, 5
1888.65	302.4	296.3	0.30	0.27	+ 6.1	+0.03	8–5	Burnham, 5; H. Struve, 3–0
1889.68	317.3	313.8	0.34	0.34	+ 3.5	±0.00	16	β., 5; Schiaparelli, 11; H. Struve, 6–0
1890.69	325.3	325.2	0.44	0.41	+ 0.1	+0.03	16	β., 4; Schiaparelli, 12
1891.68	332.4	333.5	0.42	0.48	− 1.1	−0.06	21	β., 4; Hall, 3; Schiaparelli, 9; H. Struve, 5
1892.66	339.7	339.9	0.51	0.51	− 0.2	−0.03	9	Schiaparelli, 5; Burnham, 4
1893.71	341.7	344.8	0.58	0.61	− 3.1	−0.03	24–23	Lv., 2; H.C.W., 2; Ho., 3; Com., 3; Sch., 13; Big. 1–0
1894.81	347.9	349.3	0.48	0.65	− 1.4	−0.17	14–13	H.C.W., 1–0; Schiaparelli, 13
1895.51	352.0	351.9	0.65	0.68	+ 0.1	−0.03	3	See

The present orbit is somewhat more eccentric than those heretofore published, and in this respect it conforms better to the general rule among binaries. That the orbit has an eccentricity of about this magnitude is evident from the rapid motion of the radius-vector in the periastral region, and its slow motion at the present time. The slow angular motion of the radius-vector during recent years indicates, of course, that the distance of the companion is much increased; and this leads us to remind observers that the present distance is sensibly larger than some have indicated by their measures. At present the distance is probably over 0″.65, and for some years will slightly augment.

It does not seem at all probable that the true elements of this remarkable binary can differ materially from those here obtained. Nevertheless, additional exact measures will be valuable in fixing the orbit with great accuracy, and as the star will be relatively easy for several years, observers should give it regular attention. The following is a short ephemeris:

t	θ_c	ρ_c
1896.51	355°.3	0″.71
1897.51	358.6	0.72
1898.51	1.7	0.72
1899.51	4.9	0.72
1900.51	8.2	0.69

The University of Chicago, 1895 *Aug.* 14.

OBSERVATIONS OF TWO SOUTHERN VARIABLES,

BY H. M. PAUL.

Below are my observations of two of the newer southern variables, beginning soon after the appearance of CHANDLER's Revised Supplement (*A.J.* 347) and continuing till their disappearance in the evening twilight. In moonlight and twilight they may have been estimated a little too bright on account of their color.

5511. *RS Librae.*

Gr. M.T.	M
1895 July 10.6	8.42 (1)
17.6	8.50
19.6	8.39
28.6	8.27 (2)
Aug. 11.6	8.58
1895 Aug. 18.6	8.77 (3)
25.6	8.92 (4)
Sept. 1.5	9.15 (1)
11.5	9.43

(1) Bright moonlight. (2) Very hazy; moon ($+6^{\rm d}.9$) near. (3) Hazy, faint twilight. (4) Moon ($+5^{\rm d}.5$) near.

The observations around maximum are too few to make its time very certain. A curve drawn through them gives 241 3403 (1895 July 28) as about the most probable time. CHANDLER's elements (*A.J.* 347) give 241 3413, 10 days later.

6062. *RR Scorpii.*

The following observations are based on the C.DM. magnitudes.

Gr. M.T.	M
1895 June 28.7	9.04
July 7.7	9.09 (1)
17.6	9.92 (2)
19.6	9.82
1895 Aug. 11.6	10.03
16.6	9.99
18.6	10.03
23.6	10.08
1895 Aug. 25.6	9.96
Sept. 1.6	9.96 (1)
9.6	9.95
11.5	9.87
1895 Sept. 15.5	9.76
18.5	9.59
20.5	9.54
21.5	9.52

(1) Bright moonlight. (2) Thick haze, low down, no star fainter than the variable visible.

The magnitudes of the first two dates are a little uncertain on account of a suspected, but still unsettled, variation in one of the stars of the light-scale; and that of July 17 is doubtful for the reason stated in the footnote. The slight observed irregularities around minimum are probably mostly errors of observation.

A smooth curve drawn through all the observations (disregarding that of July 17) takes a rather flat shape at minimum. The mean of the times when it passes through magnitudes 9.6 and 9.8 on each side indicates 241 3423 (1895 Aug. 17) as the most probable time of minimum, with about $10^{\rm M}.04$ as the lower limit.

There appears to be either considerable variation or considerable uncertainty in the range of brightness. CHANDLER's elements (*A.J.* 347) give for maximum $7^{\rm M}.3$ – $7^{\rm M}.7$ and for minimum $11^{\rm M}.6$. In *A.J.* 349 ROBERTS gives his observed extreme limits as $6^{\rm M}.8$ – $9^{\rm M}.3$. My above minimum of $10^{\rm M}.04$ falls between these two.

As ROBERTS does not give his observed times of maximum and minimum, there seem to be no recent data for correcting the period. Assuming CHANDLER's elements as correct, the above observed minimum at 241 3423 gives $M - m = 125^{\rm d}$, the period being $282^{\rm d}$.

Washington, D.C., 1895 *October* 8.

OBSERVED MAXIMA AND MINIMA OF VARIABLE STARS,

BY PAUL S. YENDELL.

103. *T Andromedae.*

A series of forty-six observations of this star, from 1895 July 23 to October 10, indicates a maximum on August 31.5, the magnitude at this phase being $8^{\rm M}.3$. When first observed, it was estimated at $10^{\rm M}.2$, and at the last observation was $8^{\rm M}.9$, the decrease having been remarkably slow.

The date of observed maximum is possibly affected by moonlight to the extent of several days, as on the date on which the moon became bright enough to seriously affect the comparisons, August 27, a marked and sudden rise of two steps occurs, and a corresponding sudden decrease of about the same amount is found between September 8 and 10, when the moon's presence ceases to be indicated in the notes.

2279. *T Monocerotis.*

This star was observed forty-four times, from 1894 November 19 to 1895 April 16. The following maxima and minima are indicated:

Maxima. 1894-5 Local M.T.	wt.	Minima 1894-5 Local M.T.	wt.
Nov. 13.05	2	Nov. 28.61	1
Jan. 5.34	2	Dec. 26.13	1
31.95	2	Jan. 24.11	1
Feb. 28.29	3	Feb. 15.34	1
Mar. 27.60	2	Mar. 18.91	1
		Apr. 11.74	2

2375. *S Monocerotis.*

A series of observations of *S Monocerotis* was undertaken during the winter of 1894–95, with the object of satisfying myself as to the star's variability, which has always appeared to me questionable. Thirty-one observations were obtained, from 1894 November 19 to 1895 March 3.

The comparison-stars employed, with the magnitudes assigned, are as follows:

	M
F.13 *Monocerotis*	4.8
e Geminorum	5.0
F.17 *Monocerotis*	5.1

The result of the observations seems to demonstrate the star's constancy during their continuance. The mean deviation of the star's observed brightness from a mean of $4^{M}.89$ was only $0^{M}.04$, a quantity well within the probable error of a single observation; the extreme magnitudes observed were $4^{M}.71$ and $5^{M}.04$, each upon a single occasion only.

2676. *U Monocerotis.*

Seventeen observations, from 1894 December 26 to 1895 March 23, indicate a well-determined maximum of $6^{M}.05$ on 1895 January 22, a less certainly defined one of $6^{M}.6$ on 1895 March 3, and a sharply defined minimum of $6^{M}.9$ on 1895 February 13. At the last observation the star had decreased to $7^{M}.1$.

Dorchester, Mass., 1895 *October* 14.

4511. *T Ursae Majoris.*

Fourteen observations, from 1895 March 3 to June 25, indicate a maximum of $8^{M}.0$ on 1895 May 1. At the last observation, the star had dropped to $9^{M}.4$.

6005. *S Draconis.*

Six observations of this star, from August 18 to October 10, indicate a well-defined maximum on 1895 September 24, the star's brightness at maximum having been $7^{M}.5$, and at the first and last observations $8^{M}.7$.

7085. *RT Cygni.*

From 1895 May 1 to September 24, I observed this star twenty-two times; at the first date it was just within the limit of visibility, and estimated to be about $12^{M}.0$. A maximum of $7^{M}.3$ is indicated on 1895 July 9, and at the last observation, it was estimated as $11^{M}.0$.

7118. *X Aquilae.*

This star was first observed 1895 June 10, at $9^{M}.4$; it rose rapidly to a maximum of $8^{M}.8$, which was passed July 11. At the last observation, August 8, it had again fallen to $9^{M}.5$. The observations number thirteen in all.

7450. *V Aquarii.*

Ten observations, from 1895 May 1 to October 10, indicate a maximum of $8^{M}.3$ on August 20. The star was estimated on the first date to be $9^{M}.9$, and in spite of the small number of the observations, the time of maximum is indicated quite definitely. The star's brightness when last observed was $8^{M}.9$.

7560. *R Vulpeculae.*

I have twelve observations of this star, from 1895 August 18 to October 10.

These indicate with great definiteness that the maximum took place on September 17, the greatest observed light being $7^{M}.9$. When first observed the star was $9^{M}.6$, and at the last observation had fallen to $9^{M}.1$.

OBSERVATIONS OF COMET *a* 1895 (*SWIFT*),

MADE AT THE U.S. NAVAL OBSERVATORY, WASHINGTON, D.C.,

By Prof. E. FRISBY and Assistant Astronomer GEORGE A. HILL.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1895 Washington M.T.		*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$		Obs.
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ	
	h m s			m s	′ ″	h m s	° ′ ″			
Aug. 27	13 18 12	1	24 , 6	−1 3.00	−7 28.9	0 43 45.91	+6 2 9.8	*n*9.082	0.681	H
Sept. 11	11 37 32	2	16 , 4	+1 43.45	−3 16.8	1 8 58.66	+5 59 24.4	*n*9.388	0.689	H
14	12 7 16	3	16 , 5	−1 30.84	+1 13.1	1 12 32.12	+5 50 11.7	*n*9.243	0.685	H
21	12 8 17	4	22 , 5	−0 42.62	−1 45.2	1 18 48.76	+5 22 43.1	*n*9.119	0.688	H
23	11 49 39	5	20 , 5	+0 32.08	+2 33.8	1 20 9.46	+5 13 34.3	*n*9.195	0.692	H
Sept. 27	12 34 10	6	20 , 4	+0 11.82	−2 55.6	1 22 20.89	+4 53 48.9	*n*8.629	0.692	F

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 44 45.59	+3.32	+6 9 15.8	+22.9	DM. 5°111, 4 obs., transit circle
2	1 7 11.66	+3.55	+6 2 16.2	+25.1	DM. 5°156, 4 obs., " "
3	1 13 59.36	+3.60	+5 49 3.1	+25.6	DM. 5°167, 4 obs., " "
4	1 19 27.70	+3.68	+5 24 3.8	+26.2	Anonymous (9M.2), 3 obs., transit circle
5	1 19 33.66	+3.72	+5 10 34.2	+26.3	DM. 4°247, 3 obs., transit circle
6	1 22 5.28	+3.79	+4 56 17.8	+26.7	Boss, *Astr. Gesells. Catal.*, Albany 402

The above observations have been made with the 26-inch refractor, using a power of 200 in the micrometer.

The comet appeared round, about 3′ in diameter, and upon one or two nights I could see a faint stellar point in the center of the object, of about 13M.

During the time in which I was observing the comet, I could not see that it had diminished in brightness; in fact, on the night of September 14, it was very much brighter than when I first observed it. This may, however, have been due to the very clear sky upon that night.

All the stars, except the one used by Prof. Frisby, have been observed by Messrs. Littell and King with the transit circle, and each star-place depends upon three or four observations.

1895 *October* 14.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE CINCINNATI OBSERVATORY,

BY PHILLIPS ISHAM.

1895 Cincinnati M.T.	*	No. Comp.	Planet — * Δα	Planet — * Δδ	Planet's apparent α	Planet's apparent δ	log pΔ for α	log pΔ for δ
(372).								
h m s			m s	′ ″	h m s	° ′ ″		
Jan. 31 9 49 42	1	8	+0 31.54	+1 13.2	8 1 10.44	+39 16 48.7	n9.342	9.414
Mar. 21 10 28 46	2	9	−0 34.01	+0 38.7	7 43 14.00	+29 0 29.9	9.534	0.368
22 7 51 56	3	8	+1 7.05	−0 32.8	7 43 37.99	+28 49 39.1	8.334	0.192
Nephthys (287).								
Mar. 2 10 38 25	4	8	−0 50.56	−5 28.0	10 25 47.09	+14 34 57.7	n9.119	0.570
Unitas (306).								
Apr. 19 11 19 37	5	9	+0 23.43	+1 12.6	13 27 46.95	+ 2 37 17.6	n8.506	0.719
20 10 42 29	6	8	−0 33.56	+5 35.9	13 26 54.01	+ 2 43 29.5	n8.984	0.719
22 8 41 13	7	9	−0 47.39	−2 38.0	13 25 11.85	+ 2 55 25.0	n9.470	0.723
23 11 14 13	7	9	−1 46.37	+3 57.0	13 24 12.86	+ 3 2 0.0	n7.627	0.715
24 9 13 18	8	10	−0 1.02	−2 59.7	13 23 25.14	+ 3 7 13.3	n9.356	0.718
Dembowska (349).								
May 17 12 16 58	9	8	+0 28.09	−1 52.9	15 28 34.88	−23 54 59.1	8.831	0.894
18 11 22 43	9	11	−0 25.02	−0 50.1	15 27 41.77	−23 53 56.4	n8.607	0.895
21 11 5 17	10	11	−0 25.24	+1 29.0	15 24 57.19	−23 50 20.1	n8.670	0.895
22 10 51 46	11	11	−0 4.22	+3 50.5	15 24 3.20	−23 49 2.3	n8.817	0.894
Henrietta (225).								
May 22 11 21 56	12	9	+0 1.17	+3 23.6	15 33 16.23	− 0 12 11.4	n8.260	0.747
June 13 9 47 10	13	10	+0 22.78	−1 30.8	15 20 7.38	+ 1 51 7.8	n7.930	0.727
17 9 24 20	14	7	−1 21.67	−5 2.6	15 18 30.26	+ 2 2 15.3	n8.290	0.725
18 11 24 31	14	8	−1 44.81	−2 36.3	15 18 7.12	+ 2 4 41.7	9.344	0.727
(354).								
Aug. 13 10 35 32	15	8	−1 21.84	+1 12.3	21 46 21.60	−14 39 33.9	n9.308	0.842
14 10 34 22	15	8	−2 7.29	−7 45.0	21 45 36.15	−14 48 31.2	n9.293	0.843
20 11 26 9	16	8	+0 47.19	−5 19.6	21 40 54.89	−15 41 58.9	n8.564	0.857
22 12 7 17	17	8	−0 1.81	+4 57.1	21 39 21.38	−15 59 41.9	8.836	0.858
23 11 17 41	17	8	−0 45.82	−3 22.1	21 38 37.37	−16 8 1.1	n8.924	0.859
Alkmene (82).								
Aug. 22 11 43 46	18	8	+2 27.73	−0 51.6	21 58 21.29	−16 7 36.0	n8.299	0.860
23 10 56 45	18	9	+1 39.10	−4 42.4	21 57 32.66	−16 11 26.6	n9.030	0.858

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	8 0 36.11	+2.49	+39 15 31.3	+ 4.2	Lund A.G. Zones, 2 obs.
2	7 43 46.23	+1.78	+28 59 43.8	+ 7.4	Paris 9565
3	7 42 29.19	+1.75	+28 50 1.4	+ 7.5	Paris 9544
4	10 26 35.48	+2.17	+14 40 34.1	− 8.4	9-yr. 996; Glas. 2, 896; Paris 12916
5	13 27 21.19	+2.33	+ 2 36 21.7	−16.7	Boss A.G. 4745
6	13 27 25.24	+2.33	+ 2 38 10.3	−16.7	Boss A.G. 4746
7	13 25 56.91	+2.33 +2.32	+ 2 58 19.4	−16.4	Boss A.G. 4738
8	13 23 23.83	+2.33	+ 3 10 29.2	−16.2	Eq. comp. with Boss A.G. 4708 and Cincin. 1177
9	15 28 4.01	+2.78	−23 52 49.0	−17.2 −17.3	Cincinnati, 1 obs.
10	15 25 19.64	+2.79	−23 51 31.7	−17.4	Gould G.C. 21028
11	15 21 4.62	+2.80	−23 52 35.3	−17.5	Gould G.C. 20997
12	15 33 12.41	+2.65	− 0 15 19.0	−16.0	Eq. comp. with Gould G.C. 21167 and Rad. 1890, 4027
13	15 19 41.87	+2.73	+ 1 52 52.5	−13.9	Boss A.G. 5203
14	15 19 49.22	+2.71	+ 2 7 31.2	−13.3 −13.2	Boss A.G. 5205
15	21 47 39.61	+3.83	−11 11 0.4	+14.2	W. Arg. 17082, Sant. 2043, Yarn. 9843, Palisa 446
16	21 40 3.75	+3.95	−15 36 53.1	+13.8	W. Arg. 17010
17	21 39 19.20	+3.99	−16 4 52.6	+13.6	Cincinnati, 2 obs.
18	21 55 19.60	+3.96	−16 6 59.3	+14.9 +15.1	Radcliffe 3, 5925

NOTATION OF ASTEROIDS.

Numbers have been assigned to recently discovered asteroids as follows:

BW	1895 March 21	Charlois,	Nice,	(402)
BX	May 13	"	"	(403)
BY	1895 June 20	Charlois,	Nice,	(404)

The omitted number 330 has now been assigned to 1892 *X*, Wolf, 1892 March 18.

Mr. Berberich has found that his suspicion, that *BX* was identical with (156) *Xanthippe*, is not confirmed.

NEW ASTRONOMICAL WORKS.

Catalog der Astronomischen Gesellschaft, Zone +20° *bis* +25°, *beobachtet auf der Sternwarte Berlin. von* E. Becker. Leipzig, 1895.

This catalogue of 9208 stars is just issued, and will be cordially welcomed by astronomers. The observations, made in the years 1879 to 1883, comprise all the stars of the adopted programme; seven of them, which had been omitted owing to reasons explained by Prof. Becker, having been subsequently observed by him at Strassburg, and added at the end of the catalogue. There are moreover 45, not given in the *Durchmusterung* as well as 137 companions of stars found to be double, although not recognized as such at the time of the Bonn observation. One star, DM. 22°3272, was not seen on the date when the zone was observed, nor yet when looked for by Dr. Kobold, 1895 March 6; but was found by him March 22 as 11^M, giving rise to a strong suspicion of variability.

The mean error of a single observation ranges from $\pm 0^s.022$ and $\pm 0''.38$ to $\pm 0^s.033$ and $\pm 0''.43$, according to the brightness of the star.

Elaborate investigation of the influence of the star's magnitude upon the observed time of transit has led Prof. Becker to inferences analogous to those deduced by Prof. Boss from his Albany zone. Observations made for the purpose, on 13 nights, indicate that the transits were noted earlier for brighter than for fainter stars, by an amount not far from $0^s.007$ for each unit of magnitude. For pointings in declination, analogous inquiries give less definite results; but Prof. Becker has found distinct indications of a corresponding, although unimportant, variation proportionate to the brightness of the star.

Extensive comparisons between the positions in this and in other standard catalogues are given. Among catalogues of nearly the same epoch, those of Pulkowa (Romberg) and Greenwich (ten-year) exhibit good agreement with the Berlin zone. Like the *Astr. Gesellsch.* Catalogues, the Second Munich Catalogue is differentially based upon the *Fundamental-Catalog*; but comparison with the Berlin Zone brings to view anomalies, both in right-ascension and declination, which are clearly not attributable to casual errors of observation. Systematic discordances of similar character and magnitude for right-ascension were encountered by Dr. Bauschinger in his comparison of the Munich Catalogue with the Albany Zone. (*Münch. Neue Annal.* II, p. xxxiii).

Values of proper motion are deduced for more than 600 stars of the zone; and there is a list of stars which show large discordances from other catalogues.

Comparisons of the estimates of magnitude with those of Argelander manifest a most satisfactory accordance.

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Observations of Comet *a* 1895 (Swift), by Prof. E. Frisby and Mr. George A. Hill.
Observations of Minor Planets, by Mr. Phillips Isham.
Notation of Asteroids.
New Astronomical Works.

Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office at Boston, Mass., as second-class matter. *Closed October 26.*

THE

ASTRONOMICAL JOURNAL.

No. 358.

VOL. XV. BOSTON, 1895 NOVEMBER 13. NO. 22

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

BY J. A. PARKHURST.

103. *T Andromedae.*

My observations, 16 in number, began 1895 July 24, and closed October 23. The star rose gradually from 10^{M} to a maximum of 8^{M}.0, 1895 Sept. 9. After that time the decline was much slower than the rise. The magnitude at maximum is based upon the following data:

		DM.	P.
		M	M
a	DM. +26°40	7.5	7.65
b	42	8.1	8.1
d	37	8.8	8.75

At the last observation the magnitude was 8.8.

294. *W Cassiopeae.*

The position of this new variable was measured with the filar micrometer attached to the 6.2-inch reflector. The reference points were

a	*Astr. Ges. Catal.* 717	DM. +57°163
t	718	[57°162]
x	755	58°134
s	825	57°177

The resulting position was

R.A. = $0^{h}\ 47^{m}\ 30^{s}.5$. Decl. = 57° 53′ 8″ (1875).

My observations began 1894 December 5, and closed 1895 October 23. The star rose slowly from 11^{M}.6 to a maximum of 8^{M}.6, 1895 July 11. It then fell still more slowly through July, August and September, then more rapidly in October; at the last observation it was 10^{M}.0. The observations of ESPIN, given in *A.N.*, Vol. 136, p. 397 (1894 September 2, 8.6; October 29, 9.8), suggest a minimum of about 11^{M}.5 in December, 1894. This star is No. 67 in KRÜGER'S *Catalog der farbigen Sterne*, in which the color is given as "very red."

678. *U Persei.*

I have 35 observations between 1894 Nov. 15 and 1895 October 19; yielding a maximum of 7^{M}.6, 1895 March 18, and a minimum of 11^{M}.6, 1895 July 25. From 4 maxima and 3 minima the period results,

From max., 315 days; from min., 313 days; *M–m*, 182 days.

It should be noticed that YENDELL'S maximum, 1895 January 11, published in *A.J.* XV, 35, was erroneous.

1574. *W Tauri.*

A minimum of 12^{M}.2, 1895 March 7, is indicated by 26 observations, from 1894 November 20 to 1895 April 18. At the last observation the star had risen to 10^{M}.8.

1981. *S Camelopardalis.*

My observations, 22 in number, between 1894 November 15 and 1895 June 13, yield a maximum, 8^{M}.1, 1895 March 8.

2258. *V Aurigae.*

I have 23 observations of this star, from 1894 November 20 to 1895 June 13. These indicate a minimum of 11^{M}.5, 1895 March 17. The change was slow, and as the star is quite red, and the observations not very accordant, the date of maximum may be a month late. The interval between my two observed minima is 335 days.

5157. *S Bootis.*

A minimum of 12^{M}.7, 1895 July 2, is indicated by 10 observations between 1895 April 29 and August 5.

5190. *R Camelopardalis.*

I have 19 observations of this star between 1894 November 20 and 1895 May 20, yielding a minimum of 12^{M}.5, 1895 March 16.

5338. *U Bootis.*

A minimum of 12^{M}.0 for May 14 is indicated, not very definitely, by 8 observations between 1895 April 28 and June 21.

6446. *T Draconis.*

The position of this new variable and its comparison-stars was measured with the filar micrometer, the reference points being the stars *b*, *c*, *e*, *f* and *t*, in the accompanying list. The variable has a companion "*g*", 11^{M}.2, at position-angle 226°, distance 16″, and another, "*m*," 12^{M}.3, at 288°, and 1′ 12″. The position of *T* for 1875 is

R.A. = $17^{h}\ 54^{m}\ 28^{s}.7$. Decl. = +58° 13′ 51″.

	Astr.Ges.	P.	Position 1875 R.A.	Position 1875 Decl.	Astr.Ges.	DM.
	M	M	h m s	° ′ ″		
c	8.6	8.6	17 48 31.0	58 21 30	9491	58°1767
d	8.9	8.7	49 20.6	57 41 19	9496	57°1814
t	9.4	–	50 37.3	58 11 24	9508	58°1770
l	–	11.1	52 34.9	58 9 4	–	–
b	8.7	8.6	53 15.6	58 45 46	9536	58°1772
r	–	–	53 39.4	58 8 44	–	–
k	–	11.3	53 43.5	58 9 41	–	–
p	–	–	53 51.9	57 55 49	–	–
n	–	10.6	54 7.6	57 58 29	–	–
m	–	12.3	54 20.0	57 14 16	–	–
g	–	11.2	54 27.2	57 13 42	–	–
V	–	–	54 28.7	58 13 54	–	–
f	9.4	10.1	55 17.4	58 6 57	9556	58°1773
e	9.3	9.5	56 19.2	58 28 58	9563	58°1774
h	–	9.8	56 46	58 28	–	–
a	7.6	7.6	17 57 23.7	58 46 0	9576	58°1776

I have 34 observations of the variable between 1894 Dec. 25 and 1895 October 22. It fell slowly from 8ᴹ.0 to a minimum of 11ᴹ.7, 1895 August 3, then rose quite rapidly, reaching 10ᴹ.5 September 15. It was 10ᴹ.0 at the last observation. The variable was fainter than the companion "*g*" from July 15 to August 27.

7085. *RT Cygni.*

A maximum of 6ᴹ.6 is indicated by 15 observations between 1895 May 9 and August 22, for July 9. The following are the data for the comparison-stars.

	Astr.Ges.	P.	Position 1875 R.A.	Position 1875 Decl.	Astr.Ges.	DM.
	M	M	h m s	° ′ ″		
a	9.2	7.9	19 37 45.1	48 37 2	13290	48°2935
b	7.8	7.8	37 12.2	13 14	13280	2934
h	–	10.3	38 36.0	21 6	–	–
k	–	11.	39 2.9	21 40	–	–
f	–	9.2	39 6.7	14 6	–	–
e	8.6	8.2	39 15.2	8 17	13318	2939
o	–	10.5	39 34.5	25 50	–	–
g	–	10.	39 27.1	17 1	–	–
d	8.5	8.7	39 56.0	17 36	13331	2941
l	–	9.8	40 2.0	31 56	–	–
V	–	–	40 5.0	28 42	13335	2942
c	8.3	8.4	40 7.6	37 54	13337	2943
s	–	12.0	40 6.0	29 17	–	–
t	–	12.4	39 55.6	28 59	–	–
q	–	11.3	40 12.3	28 41	–	–
n	–	10.6	40 19.2	30 8	–	–
u	–	–	41 30.6	31 40	–	–
w	–	–	19 41 18.4	48 31 3	–	–

The places of the *Astr. Gesellschaft* stars were taken from the catalogue, the rest were measured with the micrometer.

7118. *X Aquilae.*

I have 7 observations between 1895 May 26 and August 5. They yield a maximum of 9ᴹ.0, July 2. The rise was a little more rapid than the decline.

7458. *V Delphini.*

After a close watch for this star since June 1894, I saw it for the first time 1895 February 21. After that I secured the following observations:

		M			M
1895 Feb.	21	11.1	1895 July	24	11.7
May	26	10.2		30	12.2
June	15	10.8	Aug.	12	12.7
	26	11.4		25	12.6
July	9	11.6		26	12.6
	19	11.6			

These observations are too much scattered to fix the date of maximum, but they suggest a period of about 540 days.

8324. *V Cassiopeae.*

My watch on this star, which began 1894 Jan. 18, has been continuous up to the present time, with the exception of a break in September and October, 1894. In that time I observed two maxima and two minima. The results are as follows:

	Minima		Maxima	
Epoch	Calendar	Julian	Calendar	Julian
1	1894 Mar. 21	2909	1894 July 15	3025
2			1895 Mar. 2	3255
3	1895 July 5	3380		

The period deduced from the above observations is from maxima 230 days, from minima 235.5 days. Mean 232.75 days. To correct this period we have three DM. observations in 1857, and measures from the Harvard photographic plates on 18 dates, from 1890 August 4 to 1895 September 5, inclusive. The DM. observations are as follows [see *A.N.* 3205, p. 211]: 1857 August 26, <9ᴹ.5; August 30, 9ᴹ.5; Sept. 16, 9ᴹ.5. It is evident that the star was on the ascending branch of the light-curve. I find that it reaches 9ᴹ.5 about 60 days after minimum. Subtracting 60 days from the mean of the last two dates gives 1857 July 10 as the date of minimum (2399505). Combined with my observations this becomes minimum epoch −56 or −57, with a corresponding period of 235.3 or 231.2 days.

I have compared the Harvard observations with an ephemeris deduced from each of these periods, and find that 231.2 is the more probable value; the differences (O−C) of magnitude for the three observations in 1890, '91 and '92 being −1.08, −0.21 and −0.35 magnitudes, as compared with −2.60, −1.48 and +0.25 magnitudes, using the period 235.3 days.

In making the above comparisons I have drawn a mean light-curve from 91 observations, the average difference between the single curve and the mean curve being 0.134 magnitudes.

Mean Curve.

Days	From min.	From max.
	M	M
−48	11.18	9.52
−32	11.98	8.68
−16	12.50	7.91
0	12.66	7.46
+16	12.39	7.92
+32	11.47	8.56
+48	10.45	9.42

I have one observation, 1894 Nov. 15, which differs by 1M.2 from the mean curve, but this was marked "doubtful" at the time. Reliance upon this observation caused me to publish in *A.J.* XV, 100, a minimum for 1894 Nov. 24, which proves to be 16 days late. The more probable date, Nov. 8, is well supported by 4 Harvard measures. I deduce from all the above the following:

Elements of maximum.

1893 Nov. 25 (241 2793) + 231d.2 E; $M - m$ = 112d.

In connection with the Harvard measures, it should be said that a constant correction of −0M.62 has been applied to restore the photographic to the visual scale.

The data for the comparison-stars are given in the following table, in which the stars not in the *Astr. Ges. Catal.* were measured with the micrometer.

Marengo, Ill., 1895 *Oct.* 31.

	Astr.Ges.	P.	Position 1875 R.A.	Position 1875 Decl.	Astr.Ges.	DM.
	M	M	h m s	° ′ ″		
p	6.4	6.8	23 1 53.9	59 3 5	13750	58°2546
t	9.0	–	4 0.1	59 7 46	13785	(59°2652)
u	6.1	–	4 23.7	58 39 18	13794	58°2552
r	–	9.6	4 24.3	58 58 26	–	–
b	9.1	9.3	5 37.4	59 17 22	13815	59°2663
s	–	10.4	5 47.7	59 4 24	–	–
h	–	11.2	6 11.6	59 2 3	–	–
m	–	10.7	6 15.4	58 58 23	–	–
d	–	10.3	6 15.4	58 55 24	–	–
V	–	–	6 18.6	59 1 14	–	58°2560
e	–	9.9	7 6.1	58 4 40	–	–
a	8.5	8.3	8 1.9	58 16 8	13851	58°2563
c	8.5	8.6	8 34.1	59 8 23	13858	59°2673
o	7.6	7.5	23 2 7.1	58 18 48	13756	58°2547

The place of the variable depends on the *Astron. Gesell. Cat.* positions of *b*, *c*, *u* and *t*.

OBSERVATIONS OF COMETS,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 26-INCH EQUATORIAL,

BY PROF. E. FRISBY.

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

Washington M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			COMET *a* 1895 (SWIFT.)					
h m s			m s	′ ″	h m s	° ′ ″		
Oct. 18 10 49 42.0	1	20 , 7	−0 31.51	+1 58.7	1 26 47.34	+3 35 17.9	8.985	0.805
21 8 52 48.1	1	18 , 6	−0 14.68	−3 16.3	1 27 4.20	+3 29 2.9	9.501	0.717
25 11 22 39.5	1	23 , 8	+0 13.70	−7 21.7	1 27 32.62	+3 25 57.5	8.271	0.819
26 13 11 33.7	2	11 , 4	+2 37.76	−0 24.2	1 27 41.06	+3 25 47.3	9.378	0.745
			FAYE'S COMET.					
Oct. 18 9 32 2.1	3	13 , 5	−0 22.43	−5 2.4	21 11 44.76	−4 27 41.8	*n*9.388	0.776

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 27 14.87	+3.98 +4.05	+3 32 51.9	+27.3	Boss, Albany A.G. Catal. 424
2	1 24 59.25	+4.05	+3 25 44.2	+27.3	Boss, Albany A.G. Catal. 409
3	21 12 3.93	+3.26	−4 22 52.5	+13.1	Rümker 21h, 31 *Nachtrag*

TRANSIT OF *MERCURY*, 1894 NOVEMBER 9-10,

OBSERVED AT THE STUDENTS' OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA,

BY A. O. LEUSCHNER.

The observations were made with the 6-inch equatorial, and an eyepiece magnifying about 50 diameters. The times were recorded on the chronograph by means of sidereal chronometer Negus 1755. The contacts are given below in Pacific Standard Time, as deduced by Mr. F. E. Ross, student assistant.

		h m s	
Contact II	Nov. 9	19 58 40.2	geometrical contact.
		49.3	first light seen
Contact III	Nov. 10	1 11 9.9	first appearance of tangency, black drop.
		1 11 33.6	geometrical contact
Contact IV	Nov. 10	1 13 14.7	last seen.

A tree interfered at first contact. Definition poor. Sun's limb boiling. *Mercury* dancing and blurred, as though out of focus.

Berkeley, Cal., 1895 *October.*

PERTURBATIONS IN THE MOTION OF THE DOUBLE STAR F.70 *Ophiuchi* = Σ.2272.

[Letter of Dr. T. J. J. SEE to the Editor.]

Since August 20, when I first announced to you the existence of peculiar anomalies in the motion of the companion of F.70 *Ophiuchi*, I have succeeded in showing conclusively that the system is perturbed by an unseen body. We are confronted with the remarkable fact that within three years after the completion of SCHUR's orbit (*A.N.* 3220, 21), which was based on a beautiful least-square adjustment of nearly 400 observations of position-angle, the ephemeris is "out" by nearly *five degrees!* Thus for the epoch 1895.66 the ephemeris gives $\theta_c = 300°.6$, $\rho_c = 2''.12$; while the mean of 15 nights' observation, by HOUGH, COMSTOCK and the writer, gives $\theta_o = 295°.9$, $\rho_o = 2''.11$. As the error of observation in this result can by no possibility exceed half a degree, it is clear that some disturbing cause has been at work to produce so large a deviation in so short a time. On carrying back the work over the whole list of observations since the time of WILLIAM STRUVE, I find that the dark body has a period of approximately forty years; and if we suppose it to revolve around the companion, it appears that the distance of the latter from the common center of gravity of the new system is about 0''.3, and that the motion is retrograde, like that of the visible pair. It is well known that computers have encountered many difficulties with this star, the periods found ranging from 87 to 95 years, according to the observations employed. The angular motion appeared to be retarded near the aphelion of the apparent ellipse, and accelerated near perihelion. To avoid these apparent anomalies in the angular motion, Professor SCHUR neglected the distances, and ran the orbit in or out so as to conform to the principle of the conservation of areas. It will appear from the paper which I expect to forward to the *Journal* in a short time that the areas *are violated*, owing to the action of the disturbing body, and hence the apparent anomalies in angle and distance become genuine realities which are well represented by the present hypothesis. The sudden deviation of the companion from SCHUR's ephemeris proves the existence of the dark body here assumed.

The University of Chicago, 1895 *October* 31.

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1895 (SWIFT),

MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY ORMOND STONE AND GORDON M. BUCK.

1895 Charlottesville M.T.		*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$		Obs.
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ	
	h m s			m s	' ''	h m s	° ' ''			
Oct. 9	8 39 51	9	24 . 6	+0 12.56	+2 5.8	1 25 47.09	+4 2 40.4	*n*9.566	0.706	S
10	8 37 17	9	24 . 4	+0 21.35	−1 40.3	1 25 55.90	+3 58 54.4	*n*9.566	0.707	S
	9 15 25	9	11 . 2	+0 21.33	−1 33.2	1 25 55.88	+3 59 1.5	*n*9.499	0.701	B
13	12 6 8	10	32 . 4	−0 50.28	+5 15.7	1 26 18.43	+3 48 19.5	8.321	0.692	S
	13 2 46	10	24 . 4	−0 50.54	+5 8.9	1 26 18.17	+3 48 12.7	9.122	0.694	B
16	16 1 44	10	12 . 2	−0 32.48	−3 45.6	1 26 36.24	+3 39 18.1	9.621	0.715	S
17	11 16 38	10	4	. . .	−5 36.7	. . .	+3 37 27.0	. . .	0.694	S
	11 33 9	10	4	−0 27.01	. . .	1 26 41.72	. . .	*n*8.200	. . .	S
	11 39 1	11	15	−2 0.04	. . .	1 26 41.67	. . .	*n*7.593	. . .	S
18	8 39 18	12	28 . 4	−0 31.82	+2 12.1	1 26 47.03	+3 35 31.3	*n*9.510	0.705	S

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ' ''	''	
9	1 25 30.62	{ +3.91 +3.93	+4 0 7.5	{ +27.1 +27.2	Boss, A.G., Albany Catal. 416
10	1 27 4.75	{ +3.96 +3.98	+3 42 36.4	{ +27.4 +27.3	Boss, A.G., Albany Catal. 423
11	1 28 37.73	+3.98	+3 35 23.9	+27.3	Boss, A.G., Albany Catal. 437
12	1 27 14.87	+3.98	+3 32 51.9	+27.3	Boss, A.G., Albany Catal. 424

FILAR-MICROMETER OBSERVATIONS OF FAYE'S COMET,

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY ORMOND STONE.

1895 Charlottesville M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Oct. 8 7 36 32	1	20 , 3	−0 48.98	+2 54.6	21 8 14.22	−3 24 44.0	*n*8.669	0.763
9 7 38 27	1	20 , 2	−0 36.16	−4 0.2	21 8 27.03	−3 31 38.8	*n*8.400	0.764
10 7 33 29	2	24 , 4	+0 23.42	+0 14.7	21 8 42.	−3 38.3	*n*8.464	0.765
13 8 3 36	3	28 , 4	−2 50.96	−2 58.6	21 9 35.27	−3 57 51.7	8.686	0.768
16 8 45 46	4	4 , 7*	−0 11.05	−0 26.0	21 10 47.82	−4 16 6.5	9.181	0.768
17 8 25 59	5	22 , 6	−0 53.00	+0 45.1	21 11 14.21	−4 21 54.3	9.088	0.769
18 7 32 33	5	18 , 4	−0 24.78	−4 40.7	21 11 42.41	−4 27 20.1	8.473	0.772
21 8 18 53	6	1	. . .	−2 47.4	. . .	−4 43 44.5	. . .	0.769
9 1 26	7	4 , 6*	+0 1.02	−0 4.5	21 13 23.87	−4 43 52.5	9.326	0.769

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 8 59.84	{ +3.36 +3.35	−3 27 52.0	+13.4	½(First+Second) Munich Catalogue
2	21 8 15.	+3.35	−3 38.8	+13.4	S.DM. −3°5153
3	21 12 22.89	+3.34	−3 55 6.6	+13.5	Koenigsberg, Zone 19
4	21 10 55.5	+3.32	−4 15 53.7	+13.2	Schjellerup 8587
5	21 12 3.93	{ +3.28 +3.26	−4 22 52.5	+13.1	Rümker, *Nachtrag* 21h.31; S.DM. −4°5408
6	21 11 40.46	+3.23	−4 40 44.1	+13.0	Koenigsberg, Zone 19
7	21 13 19.62	+3.23	−4 43 35.0	+13.0	15½M, Microm. Comparison with * 6

* Position-angles and distances.

The Comet was at all times extremely faint and small.

ON A NEW VARIABLE OF PECULIAR CHARACTER, 8598 *U PEGASI,*

(1855) 23h 50m 35s, +15° 8′.9; (1900) 23h 52m 53s, +15° 23′.9,

BY S. C. CHANDLER.

The above star is variable from 8M.9 to 9M.7 in the singularly short period of 5h 31m.15. It is distinctly not of the *Algol*-type, being in continuous variation during its whole period. Its light-curve is also distinctly different from the form exhibited by the other class of short-period stars (exemplified by *η Aquilae* and *δ Cephei*), being symmetrical, with equal times of increase and decrease. The variation is very rapid, and maxima and minima are equally and sharply marked; so that both can be observed with the same precision with which we are familiar in the *Algol*-type stars. The shortness of the period permits the observation of three or four principal phases during a single night.

The elements are

	Greenwich M.T.	
	d h m	
Minimum, 1894 Sept.	22 14 56.0	} + 5h 31m 9s.0 E
Maximum,	22 17 41.6	

This period is probably only a moderate fraction of a second in error.

It may not be amiss to add that I discovered the variability of this star more than a year ago, but erroneously inferred that it was of the *Algol*-type, with a period of 2.06 or 2.07 days; a mistake due to the near commensurability of nine of the true periods with two solar days. Not being able to observe during last winter, I passed the star over to Mr. YENDELL's care. He confirmed the variability, but concluded that the period was 0d.69, or one-third what I had assigned; but it was still supposed to be of the *Algol*-type. It was only recently that, following up some anomalies of my observations, I succeeded finally in establishing that the period must be again subdivided by three, and that, instead of being a variable of the *Algol*-type, the star has the unique character above described.

The comparison-stars and light-scale are added for the convenience of those who may be inclined to observe the star.

	1855		L.	
	h m s	° ′		M
a	23 51 28	+15 2.2	19.0	8.85
b	50 21	14 39.6	16.5	9.10
c	52 25	14 58.5	14.5	9.30
d	24 49 41	+15 13.6	10.0	9.75

Cambridge, 1895 *October* 26.

NEW VARIABLE IN *CAPRICORNUS*, (S.DM.—16°5811),

$21^h\ 2^m.5$, —16° 46′.0 (1855).

By AARON N. SKINNER, Assistant Astronomer.

[Communicated by Prof. Wm. Harkness, Astronomical Director, Naval Observatory.]

In the course of the observation of the *Astronomische Gesellschaft* Zone, −13° 50′ to −18° 40′, I have found that the star S.DM. −16°5811 is variable, having a range at least from 9^M to $11^M.5$. I have the following notes from observations with the 9-inch Transit Circle. 1894 Sept. 24, not visible with faint field illumination; must have been as faint as 11^M; Oct. 31, estimated magnitude $9^M.0$; 1895 Sept. 24 invisible with faint field-illumination; Sept. 23, very faint about 12^M with no illumination; Oct. 4, still very faint.

Dr. Küstner, director of the Bonn Observatory, has very kindly furnished the following confirmatory evidence from the original *Durchmusterung* records.

"Zone 77, 1876 Juli 14, klare Luft, Mondschein.

9^M $21^h\ 2^m\ 32^s.2$ —16° 46′.0

Ueber dieselbe Stelle ist als zweite Zone gegangen: Zone 397, 1879 Aug. 13, meist sehr klar.

In dieser Zone fehlt der Stern. Es ist dies bereits Schoenfeld aufgefallen: er hat aber den Ort als gesichert betrachtet und in die B.D. trotz nur einmaliger Beob. aufgenommen, da er den Stern auch genau am obigen Ort in Wash. Zone 207, 1848 Oct. 11, als 9^M beobachtet fand."

This is the fourth variable which has been found in the course of the observations of our zone.

Washington, D.C., 1895 *October* 31.

OBSERVATIONS OF COMET *a* 1895 (*SWIFT*),

MADE AT GOODSELL OBSERVATORY, WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER,

By H. C. WILSON.

1895 Northfield M.T.		✱	No. Comp.	☄ — ✱		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 11	10 6 24	1	9 , 9	+0 30.20	−5 39.7	1 26 4.76	+3 54 55.1	n9.317	0.762
	10 6 24	2	9 ,	−0 25.49	. . .	. . .	. . .	. . .	. . .
	10 13 31	2	, 3	. . .	−1 28.5	. . .	. . .	. . .	. . .
16	10 49 51	3	12 , 6	−0 32.32	−3 13.3	1 26 36.40	+3 39 51.1	n9.001	0.760
17	9 34 20	3	12 , 6	−0 26.63	−5 32.8	1 26 42.10	+3 37 31.6	n9.346	0.764
21	9 45 49	4	15 , 6	−0 13.87	−3 21.5	1 27 5.10	+3 29 57.2	n9.251	0.764
23	10 0 47	4	18 , 6	−0 1.22	−5 42.5	1 27 17.77	+3 27 36.2	n9.145	0.763

Mean Places for 1895.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1*	1 25 30.62	+3.94	+4 0 7.5	+27.3	Boss Albany A.G. Catalogue 416
2	1 26 26	. . .	+3 56	. . .	DM. +3°211
3	1 27 4.75	+3.97	+3 42 37.1	+27.3	Schj. 466, Boss Albany A.G.Catal. 423
4	1 27 14.96	+4.02	+3 32 51.4	+27.3	Weisse-Bessel 1,429, Boss Alb.A.G.Catal. 121

* Rümker 705 gives $30^s.05$, $14^M.0$.

CONFIRMATIONS OF VARIABILITY.

By H. M. PAUL.

– *Capricorni*[*] = S.DM. −16°5811.

This new variable, recently discovered and announced by Mr. Skinner, I have observed on six nights. A rough reduction of the light-scale, resting mostly on three nights' observations, gives the following magnitudes of the variable, on the S.DM. scale extended downwards from about $8^M.5$.

Gr. M.T.	M	Gr. M.T.	M
1895 Sept. 27.7	10.9	1895 Oct. 14.6	9.9
Oct. 4.6	10.4 (1)	18.6	9.8
8.6	10.1 (2)	23.6	9.6

(1) Very hazy; bright moon (—$13^d.2$). (2) Clear: moonlight (—$9^d.1$).

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[*] 7590 Z *Capricorni*, p. 184.

1803. *T Leporis.*

This is one of the H.C.O. variables included by Chandler in his Revised Supplement (*A.J.* 347), but, so far as I know, not yet confirmed optically. I have observed it on eight nights. The identification with S.DM. −22°995 ($8^{M}.7$) is correct. My observations are as follows, the magnitudes resting on the S.DM. scale.

Gr. M.T.		M	Gr. M.T.		M
1895 Sept.	3.9	8.9 (1)	1895 Oct.	16.9	8.5
	15.8	8.9		22.8	8.3
	18.8	8.9		25.8	8.2
Oct.	1.9	8.6 (2)		29.9	8.1

(1) Bright moon ($-14^{d}.5$). (2) Bright moon ($+13^{d}.5$).

The star is quite red, and the estimates of Sept. 3 and Oct. 1 may be too bright on account of moonlight background.

— *Eridani** = C.DM. −24°1960.

This is one of the H.C.O. variables recently announced by Mrs. Fleming in the *Astrophysical Journal*, 2: 198. Since its announcement I have observed it on five nights. The identification with C.DM. −24°1960 ($8^{M}.6$) appears to be correct, and my observations below, taken in connection with the C.DM., would appear to be sufficient optical confirmation of its variability. The following magnitudes rest upon an extension downwards of the C.DM. scale from about $9^{M}.0$.

Gr. M.T.		M	Gr. M.T.		M
1895 Oct.	17.8	11.0	1895 Oct.	26.8	10.7
	18.8	11.0		29.9	10.3
	23.8	10.9			

Washington, 1895 *Nov.* 1.

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* 1386 *T Eridani*, see p. 184.

FROM A LETTER OF MR. BERBERICH TO THE EDITOR.

A few days ago Mr. Coniel and Mr. Capon of the *Bureau des Longitudes* at Paris sent me the elements for some of the last planets, among others those of *BZ*, *CA* and *CB*. It was evident to me at once that *CA* must be identical with (336), [1892 D], the first discovered by Charlois, with the aid of photography. There were only five observations, Sept. 20, 21, 29, at Nice, and Oct. 18 and 19 at Marseilles, or practically three positions, as the first two and last two observations are too close together. Unfortunately in the place of the middle position there was a large error (1′ in Decl.) resulting from an incorrectness in the place of the comparison-star. Of course the elements also came out quite erroneous, and gave, for 1895, a place very discordant from that at which *CA* was found. The corrected elements of (336) are now:

$$\begin{aligned}
\text{Epoch} &= \text{1892 Sept. 20.5 Berlin M.T.}\\
M &= 94^{\circ}\ 0'\ 27''.2\\
\left.\begin{aligned}\omega &= 26\ 35\ 57.8\\ \Omega &= 234\ 32\ 34.9\\ i &= 5\ 41\ 58.5\end{aligned}\right\} & \ 1900.0\\
\phi &= 5\ 20\ 28.2\\
\mu &= 1047''.590\\
\log a &= 0.353210\\
m_0 &= 11^{M}.8, \quad g = 9^{M}.6
\end{aligned}$$

The numbers of the last planets now become

(402) = 1895 *BW*, discovered by Charlois March 21
(403) = 1895 *BX*, " " " May 18
(404) = 1895 *BY*, discovered by Charlois June 20
(405) = 1895 *BZ*, " " " July 23
(406) = 1895 *CB*, " " " Aug. 22

The planet *CC* of about $11^{M}.5$, discovered by Prof. M. Wolf on Oct. 13, is probably a new one. The same plates contain a second planet $12^{M}.5$, 1895 *CD*, not yet observed directly.

In September last Mr. Charlois reobserved the planet (325) *Heidelberga* not very far from the computed place. I shall now proceed to compute the perturbations by *Jupiter*, which will be of a similar character and amount as those of (175) *Andromache*. The latter is now near opposition, and should be reobserved. An ephemeris is given in the *Astr. Jahrbuch* for 1897, p. 447.

The tables of elements and of oppositions of the minor planets for the year 1896 are now in press. The places are given for 332 planets from (1) *Ceres* to (401) *Ottilia*, with a few exceptions of planets having very uncertain orbits.

Planet (401) *Ottilia* deserves also some interest, as it possesses a mean motion of 584″ ± 3″, differing by only 14″ from the double motion of *Jupiter*. If the orbit shall be confirmed by later observations, the great gap in the zone of minor planets will be confined within the limits 584″ to 611″ instead of 572″ to 611″ as now. Therefore the fifth hundred of the group of planetoids begins with an important body, the theory of which might lead to several significant results.

Berlin, 1895 *Oct.* 29.

SUPPOSED NEW STAR IN *CARINA*.

The Boston *Herald* of Nov. 5 announces, apparently by authority, that a new star has been found by Mrs. Fleming at the Harvard Observatory, upon photographs taken at the Boyden Observatory in Arequipa by Prof. Bailey.

It does not appear upon photographs taken 1889 May 17 and 1895 March 5; but it is found upon plates taken in 1895, from April 8 to July 1, during which interval its magnitude fell from 8^{M} to 11^{M}. The star is said to precede Arg. Gen. Catal. 15269 by $0^{m}.5$, being 0°.7 north.

ASSIGNMENT OF NOTATION FOR RECENTLY DISCOVERED VARIABLES.

By S. C. CHANDLER.

No.	Star	1900.0 R.A.	1900.0 Decl.	1900 Annual Variation		1855.0 R.A.	1855.0 Decl.		Magnitude Max.	Magnitude Min.
		h m s	° ′	s	′	h m s	° ′		M	M
1386	*T Eridani*	3 50 57	−24 19.5	+2.56	+0.18	3 49 2	−24 27.6	–	7.2	11.0
2778	*W Puppis*	7 43 4	−41 57.1	2.99	−0.14	7 40 49	−41 50.6	–	9.5	12.
3261	*W Cancri*	9 4 0	+25 39.	3.52	0.24	9 1 21	+25 50	–	9.6	<13.
3417	*U Velorum*	9 29 28	−45 1.3	2.25	0.26	9 27 46	−44 52.4	–	8.1	8.5
4415	*T Crucis*	12 15 54	−61 43.6	3.24	0.33	12 13 28	−61 28.6	–	6.8	7.6
5405	*RT Librae*	15 0 47	−18 20.8	3.39	0.24	14 58 15	−18 10.1	–	8.7	11.7<
5566	*RU Librae*	15 27 41	−14 59.4	+3.35	0.21	15 25 10	−14 50.0	–	8.5	<12.
5601	*S Ursae minoris*	15 33 26	+78 58.4	−2.46	−0.20	15 35 18	+79 7.3	7	8.4	11.5
6874	*V Lyrae*	19 5 9	+29 30.0	+2.35	+0.09	19 3 24	+29 25.8	–	9.1	<12.
7590	*Z Capricorni*	21 5 3	−16 35.2	3.35	0.24	21 2 32	−16 46.0	–	9.0	11.5
8598	*U Pegasi*	23 52 53	+15 23.9	+3.06	+0.33	23 50 35	+15 8.9	0	8.9	9.7

A NEW NEBULA.

By H. C. WILSON.

While looking for FAYE's comet on the night of Oct. 8, I came across a small nebula, which, so far as I can learn, has not been observed before. Its position for 1895.0 is

R.A. = $21^h\ 6^m\ 4^s.67$; Decl. = $-2°\ 27'\ 40''.9$.

This position depends upon a micrometer-comparison. (4 bisections and 9 transits), with the seventh-magnitude star Munich 27531:

Neb. − ✱, $\Delta\alpha = -0^m\ 2^s.22$; $\Delta\delta = +6'\ 55''.8$.

The nebula is very faint, very small, and round, with a rather sharp condensation, 12^M or 13^M, in the center.

NEW ASTEROIDS.

Prof. KRUEGER announces the discovery of two others by Prof. WOLF, 1895 October 13. Their positions were

CC.	$11\frac{1}{2}^M$	Oct. 18,	$11^h\ 22^m.5$ Berlin M.T.	$\alpha = 1^h\ 38^m\ 42^s.4$.	$\delta = +23°\ 46'\ 55''$.	Daily mot. -56^s in α and 4′ southward
CD.	$12\frac{1}{2}^M$	Oct. 15.	10 2.8 Heidelb.M.T.	2 5.7	+27 37	Daily mot. -51^s in α and $1\frac{1}{2}'$ southward

NEW ASTRONOMICAL WORK.

Catalogue des Mouvements Propres de 2641 Étoiles, par M. J. BOSSERT.

The extensive researches of Mr. BOSSERT relative to proper motions, published in the first two volumes of the Catalogue of the Observatory of Paris, afforded him a range of knowledge on the subject, which he has utilized in preparing this elaborate collection.

Only those stars are included for which the annual proper motion amounts to not less than $0^s.01$ in right-ascension or $0''.10$ in declination, and is deduced from observations embracing at least 50 years.

The star-places are given for the mean equinox of 1900.0 together with their annual precessions as well as proper motions, and citation of the authorities employed.

An appendix contains 34 additional stars, chiefly derived from Prof. PORTER's Catalogue in the Publications of the Cincinnati Observatory, which was not received until the printing of this Catalogue by Mr. BOSSERT was far advanced.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office at Boston, Mass., as second-class matter. *Closed November* 11.

THE

ASTRONOMICAL JOURNAL.

No. 359.

VOL. XV. BOSTON, 1895 NOVEMBER 23. NO. 23

ON THE VALUE OF THE PRECESSIONAL CONSTANT,

By SIMON NEWCOMB.

In my work on the *Fundamental Constants of Astronomy*, I made only a rapid and hasty determination of the constant of precession, and finally adopted a value of that constant based on some results which I worked out when Ludwig Struve's discussion of the subject first appeared. That I did not enter more carefully into the subject was due to two reasons. The constant of precession is so disconnected from the other astronomical constants that no admissible change in its value will materially affect the other constants. It is also not possible to make any determination at the present time which can lay claim to extreme precision. The circumstances which tend to weaken the determination diminish the evil of any inaccuracy in the adopted quantity.

Since the publication of the work this rapidity of treatment has assumed in my eyes the appearance of a serious blemish. I have been troubled all the more from a suspicion that my adopted value of the precessional motion is too small. I have therefore determined to go into the subject more fully than was done in my book, with the object of presenting the results to astronomers in such a form that they can readily determine whether it is better to adhere to the value there given, or to adopt some other.

For the sake of perspicuity I begin by repeating certain statements of the nature of the problem, which I have made elsewhere. The motion to be determined is that of the equinox upon the celestial sphere, regarded as fixed.

One difficulty met with arises from the proper motions of the stars. The *Stellarum Fixarum Sphaera Immobilis* of Copernicus can be realized only by eliminating these motions. No doubt the stars of smallest magnitude which can be accurately determined will ultimately be taken as determining this sphere. But the systematic errors affecting observations of these stars, of which I shall hereafter speak, render it advisable to depend on stars of larger magnitude, especially those observed by Bradley. After careful consideration it seems to me that the probable error in the general mean of all the stars thus observed, arising from proper motion, will be materially less than that of the systematic errors in observing the fainter stars.

Another complication is introduced by the fact that even the Bradley stars are not compared directly with the sun, but only with the fundamental or clock stars, which are themselves compared with the sun. Thus the problem divides itself into two parts; the fixing of the equinox among the stars, or the determination of the common correction to the right-ascensions of all the fundamental stars, and a determination of the smaller stars relative to the fundamental ones. I leave out of consideration the third step, that of determining the sun's absolute longitude, because I conceive this is already done with sufficient precision.

In the work already alluded to, Ludwig Struve derived the precessional motion from the observed changes both in the right-ascensions and the declinations of stars, and combined the results. What I now propose to do is to re-solve his equations in such a way as to determine what I have called the "precessional constant." The term "constant of precession" is commonly taken to mean the annual motion of the equinox in longitude, which is really not constant. To avoid confusion with this annual motion, I apply the above term to the quantity which lies at the base of the theory, and which, although not an absolute constant, varies so slightly that it may be regarded as such during a period of one or two centuries. From its value, P, the precessional motions are obtained by the equations

$$\begin{aligned} m &= P\cos^2\varepsilon + \pi\sec\varepsilon \\ n &= P\sin\varepsilon\cos\varepsilon \\ p_0 &= P\cos\varepsilon \\ p &= p_0 + \pi \end{aligned}$$

Here p_0, p and π are the lunisolar, general and planetary precessions in longitude.

I propose to combine L. Struve's equations to the single end of obtaining the value of P. Struve's numerical result rests upon the equinox of Auwers-Bradley in 1755, and that of the mean of the Pulkowa standard catalogues for 1845 and 1865. The interval is 100 years. As the position of the equinox at the time of Bradley cannot be regarded as absolutely determined, I shall introduce a symbolic correction Δa to the centennial motion of the equinox in R.A. as determined by Auwers-Bradley in 1755, and Pulkowa in 1855.

In forming the normal equation, STRUVE first takes as unknown quantities the corrections Δm and Δn to the quantities which determine the precessional motion of the stars. I cannot find that he explicitly states to what values of these quantities his corrections apply, but I assume that they are the values of O. STRUVE. He also includes three unknown quantities, X, Y and Z, depending upon the solar motion in space, and a quantity, u, expressive of a common rotation of the stellar system in the plane of the galaxy. If this motion exists at all, it is undoubtedly so small that no accurate determination of it is possible at the present time. I shall therefore suppose it zero. With this modification, and the addition of the terms in Δa, STRUVE's normal equations may be written as follows:

From the Right-Ascensions.

$$\begin{array}{rrrrcl}
92.7\,\Delta m & +\ 4.8\,\Delta n & +10.3\,X & -10.7\,Y & = & -204''.4 + 92.7\,\Delta a \\
+\ 4.8 & +10.6 & +19.2 & +\ 1.8 & = & -\ 15.9 +\ 4.8 \\
+10.3 & +19.2 & +65.2 & +\ 3.1 & = & -\ 47.5 + 10.3 \\
-10.7 & +\ 1.8 & +\ 3.1 & +61.9 & = & -253.9 - 10.7
\end{array}$$

From the Declinations.

$$\begin{array}{rrrrcl}
63.3\,\Delta n & +23.1\,X & -\ 1.6\,Y & -\ \ 7.7\,Z & = & -\ 76''.2 \\
+23.1 & +17.6 & -\ 1.4 & -\ \ 2.9 & = & -\ 23.7 \\
-\ 1.6 & -\ 1.4 & +16.5 & -\ \ 3.7 & = & -\ 50.7 \\
-\ 7.7 & -\ 2.9 & -\ 3.7 & +105.0 & = & +228.2
\end{array}$$

From these equations we now investigate the motion of precession thus:

Put P, the precessional constant
ε, the obliquity of the ecliptic.

Then taking the solar century as the unit of time, we have, for 1850,

$$m = P \cos^2 \varepsilon - 13''.42$$
$$n = P \sin \varepsilon \cos \varepsilon$$

I have adopted in my discussion of the subject,

$$P = 5489''.78$$

Let us put δP for the correction to this value, so that for 1850,

$$m = 4606''.36 + 0.842\,\delta P$$
$$n = 2004''.79 + 0.365\,\delta P$$

O. STRUVE has, for 1850,

$$m = 4607''.65$$
$$n = 2005''.64$$

Thus the symbolic corrections to O. STRUVE's quantities are

$$\Delta m = -1''.29 + 0.842\,\delta P$$
$$\Delta n = -0''.85 + 0.365\,\delta P$$

These values of Δm and Δn are to be substituted in L. STRUVE's normal equations in such way as to reduce them to normal equations in δP. In the second set this is done by simple substitution and multiplication by 0.365; in the first set by forming the linear combination of the first two equations,

$$(1) \times 0.842 + (2) \times 0.365$$

and then making the above substitutions. Then, by adding the corresponding normal equations in R.A. and Decl., we have, for the final normal equations,

$$\begin{array}{rrrrcl}
78.5\,\delta P & +21.1\,X & -\ 8.9\,Y & -\ \ 2.8\,Z & = & -\ 76''.6 + 79.8\,\Delta a \\
21.1 & +82.9 & +\ 1.7 & -\ \ 2.9 & = & -\ 22.2 + 10.3 \\
-\ 8.9 & +\ 1.7 & +81.4 & -\ \ 3.7 & = & -318.2 - 10.7 \\
-\ 2.8 & -\ 2.9 & -\ 3.7 & +105.0 & = & +221.7
\end{array}$$

The solution gives

$$\begin{array}{rcl}
\delta P & = & -1''.45 + 1.08\,\Delta a \\
X & = & +0.30 - 0.19\,\Delta a \\
Y & = & -3.99 + 0.01\,\Delta a \\
Z & = & +1.91 + 0.02\,\Delta a \\
P & = & 5488.33 + 1.08\,\Delta a \\
m & = & 4605.15 + 0.91\,\Delta a \\
n & = & 2004.26 + 0.40\,\Delta a \\
p & = & 5022.39 + 0.99\,\Delta a
\end{array}$$

The value of m obtained by L. STRUVE is 4605''.54, a result greater by 0''.39 than the above. His treatment of the normal equations differs in two points from the preceding one. For the common fundamental quantity to be determined he takes the correction to the lunisolar precession, while I have taken the correction to the precessional constant. Moreover, instead of combining the equations in right-ascension and declination into a single set of normals, as is done above, he derives the correction to the fundamental quantity by separate solutions of the equations in right-ascension and in declination, using in each set the values of X, Y and Z derived from that set, and then combining the two results. The first of the above deviations should not lead to any difference between the final results of the two methods, and I do not think the second would result in so large a difference as 0''.39. I have, therefore, made a conjectural revision of STRUVE's final derivations in the following way. At the top of page 24 he gives (omitting an unimportant term) the following result for the lunisolar precession,

$$\frac{d\psi}{dt} = 50''.3514 + 0''.0097 \left(\Delta \frac{d\lambda}{dt} + \mu \right)$$

Here μ is the systematic correction of the proper motion in right-ascension, which is necessarily left out of consideration.

L. STRUVE does not state what value of $\Delta \frac{d\lambda}{dt}$ he adopts, but as 50''.3514 is also his finally adopted value of the lunisolar precession, I assume that he takes it as zero. It is also to be remarked that this finally adopted value of the lunisolar precession is found by applying his finally derived correction from the equations of condition to O. STRUVE's original value as derived by PETERS in his *Numerus Constans Nutationis*, page 71 (or 195), without allowing for any change in the planetary precession. We must now find the change he makes in PETERS's value. The value of m for 1800 given by PETERS is the one which has been extensively used ever since, as STRUVE's number, namely,

$$m = 4606''.23$$

If from this value of m, and the STRUVE value of the lunisolar precession, 5037''.98, we find the planetary precession in right-ascension by the equation

$$\frac{d\lambda}{dt} = \frac{d\psi}{dt}\cos\varepsilon - m$$

the result is

$$\frac{d\lambda}{dt} = 15''.08$$

The value given by PETERS in the same connection is

$$15''.12$$

I do not know how to account for the difference of 0''.04, but it is of no importance in our present discussion.

But the value of the planetary precession in right-ascension, finally derived and adopted by L. STRUVE, is

$$\frac{d\lambda}{dt} = 14''.58$$

This corresponds to a correction

$$\Delta\frac{d\lambda}{dt} = -0''.54$$

If we adopt this correction, and substitute it in STRUVE's fundamental equation for $\frac{d\psi}{dt}$ given above, the centennial values of the lunisolar precession and m become, for 1800,

$$\frac{d\psi}{dt} = 5034''.62$$

$$m = 4603''.70$$

and for 1850, $$m = 4605''.07$$

This result is now smaller than mine by only 0''.08, a difference which may well be due to the difference in the method of treatment.

It will be seen that the definitive precession depends on the adopted value of $\Delta\alpha$, the correction to that common centennial motion of the stars in right-ascension which is derived from a comparison of Auwers-Bradley with the mean of the Pulkowa Catalogues of 1845 and 1865. Taking as the basis of comparison my own system of right-ascensions as found in the catalogue in Vol. I of the *Astronomical Papers*, and reproduced in the *American Ephemeris* for the years 1881 to 1899, and designating this system as N_1, I find,

$$N_1 - \text{Pulk. } 1855 = +0^s.006$$

$$N_1 - \text{A.-B. } 1755 = -0^s.114$$

Thus, to reduce L. STRUVE's comparison to N_1, we have

$$\Delta\alpha = +0^s.120 = 1''.80$$

The value $-0^s.114$ for $N_1 - \text{A.-B. } 1755$, is found by a comparison with 97 time-stars of the *American Ephemeris*. It is markedly larger than the previous values which I have assigned to this correction. The difference arises from a systematic discordance between the results from the time-stars in general, and from the MASKELYNE fundamental stars. The latter give with remarkable accordance the value $-0^s.063$ if *α Piscis Austrini* is omitted, and $-0^s.066$ if it is included. There being 31 fundamental stars, and 66 other time-stars used in the comparison, it follows that there is, at the epoch 1755, a systematic discordance of about $0^s.075$ between the results from the ancient fundamental stars, and from time-stars of smaller magnitude. For this discordance we have a *vera causa* in the now well established fact of an error in the chronographic registration of transits, depending on the magnitude of the star. In my derivation of the fundamental right-ascensions, I made no allowance for this error, although I pointed it out 25 years ago in the special case of the Washington Transit Circle (*Washington Observations*, 1867, Appendix III, page 27). But in this passage I only mentioned the effect with especial reference to the observations of the Transit Circle, and did not apply any general correction to chronographic results.

We must therefore expect that since the introduction of the chronographic method, the right-ascensions of the brighter stars, as computed from observations, have been relatively too small, and those of the fainter stars too great. The proper motions will be relatively erroneous in the same way; and it is readily seen that the effect will be to make the computed right-ascensions of the faint stars for 1755 too small, and those of the brighter stars too great. I think that the actual value of the mean correction should be somewhat less than the mean of all the stars, and should be derived by giving somewhat greater weight to the results from the brighter stars which are observed more frequently. But no definitive value of the correction can be obtained at present.

It is readily seen that a corresponding error, yet larger in magnitude, will creep into any value of the constant of precession derived from a comparison of the right-ascensions of faint stars observed by LALANDE with corresponding determinations made in recent times by means of the chronograph. Such a value of the constant we must expect to come out markedly too large, unless the proper correction is applied for the cause in question.

In my discussion of the motion of the equinox (*Constants*, page 88, and *Astr. Journ.* XIV, page 187), I have given data for a correction of N_1 based not only on observations of the *Sun*, but of *Mercury* and *Venus*. Allowing for the changed value of the terms of long period in the motion of the *Earth*, the correction to LEVERRIER's centennial motion of the *Sun* in longitude which I finally adopted is equivalent to a correction of $-1''.00$. Using this, the following values of $\Delta\alpha - N_1$ follow.

From observations of the *Sun*,		$-0''.37$	wt. 2
" " "	*Mercury*,	$+1.05$	" 3
" " "	*Venus*,	$+0.20$	" 2
	Mean,	$+0.40$	

I feel that there is much room for difference of opinion as to the relative weights of these three results. The weights 2, 3 and 2 are the outcome of judgement, not of computation.

Designating the system thus reached as N_2, we have

$$\Delta\alpha = +2''.20$$

The $\Delta\alpha$ for AUWERS's A.G. system differs from N_1 about $0''.10$. Hence, for this system we have

$$\Delta\alpha = 1''.80 - 1''.50 = +0''.30$$

The following are the values of the annual precessional motions for 1850 arranged in the order of magnitude, which correspond to these systems, inserting in its proper place, as N_0, the value which I adopted in my discussion of the fundamental constants, and adding the O. STRUVE values of m and n, which, however, are not theoretically accordant with the present system. We put

p = annual general precession in longitude.
p_0 = annual lunisolar precession.

	$\Delta\alpha$	p	p_0	m	n
	″	″	″	″	″
A.G.(—AUWERS)	+0.30	50.2269	50.3500	46.0542	20.0438
N_0	+1.33	50.2371	50.3602	46.0636	20.0479
N_1	+1.80	50.2417	50.3648	46.0678	20.0498
N_2	+2.20	50.2457	50.3689	46.0716	20.0514
O. STRUVE	–	–	–	46.0765	20.0564

MICROMETRICAL MEASURES OF DOUBLE STARS,

MADE WITH THE 40-CM. REFRACTOR OF THE WASHBURN OBSERVATORY OF THE UNIVERSITY OF WISCONSIN, 1895 SEPT. 18 TO SEPT. 29,

BY T. J. J. SEE.

The following micrometrical measures of double stars were made with the 40-cm. refractor of the Washburn Observatory, during the latter part of September. This excellent instrument and all other facilities of the observatory were kindly placed at my disposal by courtesy of the director, Prof. GEORGE C. COMSTOCK, to whom I take pleasure in acknowledging my warmest thanks. The aim was to secure measures of certain stars for which satisfactory orbits can now be determined, but as most of these objects are very close and difficult, and the weather was somewhat unfavorable, a number of relatively easy STRUVE stars were picked up at moments when more difficult pairs could not be observed. Mr. F. R. MOULTON, graduate student in Astronomy at the University of Chicago, rendered considerable assistance in the work, and in several instances made independent measures.

The approximate places of the stars are taken from catalogues referred to the equator and mean equinox of 1880.0.

η *Cassiopeae* = Σ 60.

$\alpha = 0^h\ 42^m$. $\delta = +57°\ 11'$.

	°	″	
1895.729	205.5	1.82	unsteady
1895.735	203.1	1.75	good seeing
1895.732	204.3	1.78	

Mr. MOULTON found:

	°	″	
1895.732	205.9	1.74	2 nights

F 36 *Andromedae* = Σ 73.

$\alpha = 0^h\ 48^m$. $\delta = +22°\ 53'$.

	°	″	
1895.723	14.3	1.4 ±	
1895.729	14.4	1.39	unsteady
1895.735	13.2	1.41	good result
1895.729	14.0	1.40	

Mr. MOULTON's measures give an angle of 14°.2.

γ *Andromedae* B.C. = *O*Σ 205.

$\alpha = 1^h\ 56^m$. $\delta = +41°\ 45'$.

	°	″	
1895.718	133.0	<0.3 ±	elongated
1895.723	117.8	0.28	excellent
1895.729	112.8	0.30	elongated
1895.723	121.2	0.29	

Mr. MOULTON found:

	°		
1895.723	115.3		elongated, 1 night

This pair is still very close but is gradually widening out, the companion following substantially the orbit found by BURNHAM in *Monthly Notices*, December, 1893.

F 20 *Persei* = β 524.

$\alpha = 2^h\ 46^m$. $\delta = +37°\ 51'$.

	°	″	
1895.723	252.1	0.16 ±	elongated
1895.729	251.0	0.17 ±	sharp elong.
1895.726	251.5	0.16 ±	

This excessively close pair could only be elongated and the distance estimated.

β 883.

$\alpha = 4^h\ 45^m$. $\delta = +10°\ 52'$.

	°	″	
1895.745	186.0	0.43	good images
1895.746	186.8	0.35 ±	separated
1895.745	186.4	0.39	

MR. MOULTON's setting of the micrometer gave:

	°		
1895.745	188.9		separated

This rapid system is now within reach of ordinary telescopes, and should be given some attention by observers. It will soon be possible to get a good orbit of this interesting pair.

φ Ursae Majoris = *OΣ* 208.

α = 9h 43m. δ = +54° 38′.

	°	″	
1895.723	276.8	0.33 ±	unsteady
1895.724	278.1	0.29	
1895.745	273.6	0.25 ±	uncertain
1895.731	276.2	0.29	

This pair is now excessively close and difficult, and as the companion will be moving more rapidly than usual it ought to be given particular attention by astronomers with large telescopes.

OΣ 234.

α = 11h 24m. δ = +41° 58′.

	°	″	
1895.745	155.1	0.36 ±	close

OΣ 235.

α = 11h 25m. δ = +61° 45′.

	°	″	
1895.745	97.6	0.80	separated
1895.746	97.1	0.82 ±	
1895.745	97.3	0.81	

OΣ 269.

α = 13h 27m. δ = +35° 32′.

	°	″	
1895.745	235.4	0.44	separated

ξ Bootis = Σ 1888.

α = 14h 46m. δ = +19° 36′.

	°	″	
1895.663	226.8	2.58	with Dearborn 18-inch
1895.718	222.8	2.52	
1895.723	222.7	2.58	excellent
1895.729	222.7	2.60	blurred
1895.708	223.7	2.57	

Mr. Moulton obtained:

	°	″
1895.729	224.4	2.65 ±

OΣ 298.

α = 15h 32m. δ = +40° 13′.

	°	″	
1895.745	179.7	0.99	good images
1895.746	179.1	0.91	well separated
1895.745	179.4	0.95	

Mr. Moulton found:

	°	″
1895.745	177.2	1.05

σ Coronae Borealis = Σ 2032.

α = 16h 10m. δ = +34° 10′.

	°	″	
1895.718	208.3	4.32	
1895.723	208.1	4.08	
1895.729	210.1	4.37	blurred
1895.723	208.9	4.26	

λ Ophiuchi = Σ 2055.

α = 16h 25m. δ = +2° 15′.

	°	″
1895.732	45.6	1.47
1895.735	45.8	1.49
1895.733	45.7	1.48

Δ *ad* Σ 2091.

α = 16h 40m. δ = +43° 42′.

	°	″	
1895.745	340.6	0.45	good seeing

F 210 *Herculis* = Σ 2120.

α = 17h 0m. δ = +28° 16′.

	°	″	
1895.723	244.3	7.23	
1895.729	244.3	7.16	good images
1895.732	243.7	7.03	
1895.728	244.1	7.14	

μ Draconis = Σ 2130.

α = 17h 3m. δ = +54° 38′.

	°	″	
1895.732	153.7	2.53	
1895.745	151.1	2.14	blurred
1895.738	152.4	2.34	

β 416 = Lac. 7215.

α = 17h 11m. δ = −34° 51′.

	°	″	
1895.735	320	1.0 ±	bad seeing
1895.745	322.8	0.99	separated
1895.740	321.4	0.99	

A rapid binary system of great interest. The components are now widening out, and measures ought to be secured annually until the orbit is well determined.

μ Herculis BC = A.C. 7.

α = 17h 41m. δ = +27° 48′.

	°	″	
1895.729	223.2	1.16	images faint
1895.732	224.1	1.10	seeing excellent
1895.730	223.7	1.13	

NEW COMPANION OF *μ Herculis*: *μ Herculis AD*.

While measuring the Clark pair on Sept. 24, under specially favorable seeing, I discovered that the bright star has a faint companion of the 13th magnitude, which seems to have escaped all previous observers.

Measures on two nights gave:

	°	″
1895.725	304.8	10. ±
1895.745	306.8	10. ±
1895.735	305.8	10. ±

In spite of the considerable distance of the companion and its excessive faintness, the object is worthy of the attention of observers with large telescopes. The color of the companion is bluish, like that of the Clark pair; and, as *μ Herculis* is a reddish star, the system AD strongly resembles *Aldebaran*, except that this companion is far more difficult — indeed the most difficult object I have ever examined. The appearance of the pair suggests a strong probability of physical connection, and if this should be established by future observations *μ Herculis* would become a quaternary system of great interest. It will assist an observer to locate the companion to remark that it lies in the right angle of a triangle formed by the Clark pair and *μ Herculis*. The new star will certainly prove to be a good test object for the power of telescopes. Mr. MOULTON also recognized the faint object on two evenings, though with difficulty, and only at favorable moments of seeing.

τ Ophiuchi = Σ2262.

$\alpha = 17^{h}\ 57^{m}$. $\delta = -8^{\circ}\ 11'$.

	°	″	
1895.718	254.3	1.89	
1895.723	253.4	1.84	
1895.729	255.2	1.90	
1895.732	256.0	1.82	good seeing
1895.725	254.7	1.86	

Mr. MOULTON found:

	°	
1895.729	77.8	2 nights

F 70 *Ophiuchi* = Σ2272.

$\alpha = 17^{h}\ 59^{m}$. $\delta = +2^{\circ}\ 33'$.

	°	″	
1895.715	295.3	1.98	
1895.718	296.2	2.05	
1895.723	296.4	2.08	
1895.729	295.5	2.00	good seeing
1895.721	295.8	2.03	

Mr. MOULTON found:

	°	″	
1895.723	296.2	2.21	3–1 nights

F 99 *Herculis* = A.C. 15.

$\alpha = 18^{h}\ 2^{m}$. $\delta = +30^{\circ}\ 33'$.

	°	″	
1895.723	313.6	1.0 ±	
1895.729	317.7	1.15	
1895.732	314.2	1.22	companion reddish
1895.728	315.2	1.12	

Mr. MOULTON obtained:

	°	
1895.729	313.4	2 nights

ε_1 *Lyrae* = Σ2382.

$\alpha = 18^{h}\ 40^{m}$. $\delta = +39^{\circ}\ 33'$.

	°	″	
1895.745	12.6	2.74	images blazing

ε_2 *Lyrae* = Σ2382.

$\alpha = 18^{h}\ 40^{m}$. $\delta = +39^{\circ}\ 29'$.

	°	″	
1895.745	129.6	2.10	images blazing

ζ Sagittarii (WINLOCK).

$\alpha = 18^{h}\ 55^{m}$. $\delta = -30^{\circ}\ 3'$.

	°	″	
1895.737	193.1	0.20 ±	very close

γ Coronae Austrinae.

$\alpha = 18^{h}\ 58^{m}$. $\delta = -37^{\circ}\ 14'$.

	°	″	
1895.729	156.5	1.57	separated
1895.732	161.9	1.60	well separated
1895.730	159.2	1.59	

Mr. MOULTON found:

	°	
1895.730	164.1	2 nights

δ Cygni = Σ2579.

$\alpha = 19^{h}\ 41^{m}$. $\delta = +44^{\circ}\ 50'$.

	°	″	
1895.723	310.7	1.68	difficult
1895.729	305.4	1.85	
1895.726	308.0	1.77	

*O*Σ400.

$\alpha = 20^{h}\ 6^{m}$. $\delta = +43^{\circ}\ 36'$.

	°	″	
1895.729	352.2	0.29 ±	clearly elongated
1895.732			elongation doubtful
1895.745	341.5	0.18 ±	uncertain
1895.735	346.8	0.23	

This result is somewhat doubtful; the star is now excessively close, and as this will correspond to a rapid angular motion of the companion, further observations are desirable.

λ Cygni = *O*Σ413.

$\alpha = 20^{h}\ 43^{m}$. $\delta = +36^{\circ}\ 3'$.

	°	″	
1895.723	62.2	0.65 ±	
1895.729	57.6	0.91	blurred
1895.732	62.7	0.76	
1895.728	60.8	0.77	

Mr. MOULTON:

	°	″	
1895.729	68.9	0.60 ±	1 night

F 4 *Aquarii* = Σ2729.

$\alpha = 20^{h}\ 45^{m}$. $\delta = -6^{\circ}\ 5'$.

	°	″	
1895.723	191.3	0.33 ±	elongated
1895.735	178.5	0.29 ±	
1895.737	182.7	0.38	est. 0″.32 ±
1895.732	184.2	0.33	

τ Cygni = A.C. 13.

$\alpha = 21^{h}\ 10^{m}$. $\delta = +37^{\circ}\ 32'$.

	°	″	
1895.723	327.3	0.3 ±	
1895.729	330.9	0.28 ±	
1895.732	339.5	0.3 ±	unsteady
1895.728	332.6	0.29 ±	

μ Cygni = Σ2822.

$\alpha = 21^{h}\ 39^{m}$. $\delta = +28^{\circ}\ 12'$.

	°	″	
1895.732	121.9	2.89	
1895.745	122.7	2.76	images blazing
1895.738	122.3	2.83	

ζ Aquarii = Σ2909.

$\alpha = 22^{h}\ 23^{m}$. $\delta = -0^{\circ}\ 38'$.

	°	″	
1895.723	322.6	3.00	
1895.729	323.3	3.26	images blazing
1895.745	322.9	3.11	images blazing
1895.732	322.9	3.12	

F 85 *Pegasi* = β 733.

$\alpha = 23^h\ 56^m. \qquad \delta = +26°\ 27'.$

	°	″	
1895.723	198.6	0.6 ±	
1895.737	196.3	0.83	
1895.745	200.3	0.75	est. 0″.70 ±
1895.735	198.4	0.73	

Mr. Moulton obtained:

	°	″	
1895.737	204.8	0.75 ±	2 nights

Σ 3062.

$\alpha = 23^h\ 59^m. \qquad \delta = +57°\ 46'.$

	°	″
1895.718	333.0	1.57
1895.723	333.0	1.58
1895.729	334.4	1.59
1895.735	336.9	1.36
1895.726	334.3	1.53

The University of Chicago, 1895 *Oct.* 2.

EPHEMERIS OF VARIABLES OF THE *ALGOL*-TYPE,

1895–1896 Greenwich Mean Time.

By PAUL S. YENDELL.

		h
	1895 December	
1	λ Tauri	18
	S Cancri	19
2	Algol	11
3	*Y* Cygni	14
	U Cephei	16
5	Algol	8
	λ Tauri	17
	R Can. Maj.	18
6	*Y* Cygni	14
8	*U* Cephei	16
9	*Y* Cygni	14
	λ Tauri	16
12	*Y* Cygni	14
13	λ Tauri	15
	U Cephei	15
13	*R* Can. Maj.	16
14	*R* Can. Maj.	19
15	*Y* Cygni	14
16	Algol	19
17	λ Tauri	13
18	*Y* Cygni	14
	U Cephei	15
19	Algol	16
20	*S* Cancri	18
21	λ Tauri	12
	Y Cygni	14
22	Algol	13
	R Can. Maj.	19
23	*U* Cephei	15
24	*Y* Cygni	14
25	Algol	10
	λ Tauri	11
27	*Y* Cygni	14
28	*U* Cephei	14
29	λ Tauri	10
30	*Y* Cygni	14
	R Can. Maj.	18
	1896 January	
2	λ Tauri	9
	U Cephei	14
5	*R* Can. Maj.	10
	Algol	20
6	λ Tauri	8
	R Can. Maj.	13
6	*U* Coronae	23
7	*U* Cephei	14
	R Can. Maj.	17
8	Algol	17
	R Can. Maj.	20
10	λ Tauri	7
11	Algol	14
12	*U* Cephei	13
13	*R* Can. Maj.	9
	U Coronae	20
14	Algol	11
	R Can. Maj.	12
15	*R* Can. Maj.	16
16	*R* Can. Maj.	19
17	*U* Cephei	13
21	*R* Can. Maj.	8
22	*R* Can. Maj.	12
	U Cephei	13
23	*R* Can. Maj.	15
24	*R* Can. Maj.	18
27	*U* Cephei	12
	S Cancri	16
28	Algol	19
29	*R* Can. Maj.	7
30	*R* Can. Maj.	11
31	*R* Can. Maj.	14
	Algol	16

NOTE ON THE NEW VARIABLE 8598 *U PEGASI*,

By PAUL S. YENDELL.

In September, 1894, Dr. Chandler called my attention to this star as being probably a variable of the *Algol*-type, with a period of $2^d.06$ to $2^d.07$.

I at once began observations on the star, and on October 18, 19, 27 and Nov. 3, was so fortunate as to secure evidence fully confirmatory of the fact of the star's variability. The observed times, however, were not compatible with the period suggested by Dr. Chandler, and strongly indicated that the actual period was some fraction thereof, most probably one-third. Observations were continued until late in January, 1895, without yielding further conclusive evidence on the question of the period.

The watch on the star was again taken up in September of the current year, and on the 13th of the month I had the good fortune to recover the minimum, followed by another on the 15th. These minima did not decide the question as to the period, as both, together with the two best observed minima of 1894 were well satisfied by Chandler's period. On September 24, however, an uncommonly certainly determined minimum was obtained, which showed beyond a doubt that the real period is not greater than $16^h\ 34^m$. The observations, however, show large anomalies, as yet unexplained, as the residuals exhibited are altogether too great to be considered as observational errors, the more especially as the star's light-changes are very rapid, and the phases exceptionally distinctly defined.

The comparison-stars employed, with the light-scale and magnitudes deduced from my observations, are as follows:

	DM.		Y.	Light
		M	M	
a	= 15°4916	8.8	8.80	20.0
b	= 14°5078	9.3	9.10	15.7
c	= 14°5080	9.5	9.28	13.0
g	= 15°4909	9.5	9.54	9.1
d	= 15 4910	9.5	9.60	8.4
h	= 15°4912	9.5	9.79	5.6

The actually observed minima are as follows:

Local Mean Time		d	h	m	wt.	Local Mean Time		d	h	m	wt.
1891	Oct.	18	7	55	3	1895	Sept.	24	9	8	5
		19	7	7	3		Oct.	14	10	9	5
		27	8	20	4			18	13	3	4
	Nov.	3	6	17	3			19	7	5	4
1895	Sept.	13	8	1	3			21	8	48	4
		15	10	0	3						

Besides the above actually observed times, a minimum was inferred on 1895 January $24^{d}\ 8^{h}\ 17^{m}$, from 7 observations during the star's decrease. This is from the nature of the case very uncertain, as the star was low at the time of observation, and it is not yet possible to form any useful mean light-curve.

Dorchester, 1895 *Oct.* 29.

Since the above was written, I have obtained, on the evening of Nov. 3, a minimum and the maximum immediately following, the observed times being as follows:

Minimum, $6^{h}\ 56^{m}$ good
Maximum, $9^{h}\ 27^{m}$ not quite so certain

These corroborate the discovery by Dr. CHANDLER of the true character of the star's variability, and the minimum, given above, of 1894 October 19, gives, with the elements based on the period of $0^{d}.69028$, a residual of $+5^{h}\ 34^{m}$, which is confirmatory of the value of the period found by him.

Dorchester, 1895 Nov. 5.

COMET *c* 1895.

A telegram from Prof. SCHAEBERLE at Mt. Hamilton, says:

"A bright comet, with a tail, was discovered by PERRINE, at the Lick Observatory, in the position,

1895 Nov. 17.060 Greenw. M.T. $\alpha = 13^{h}\ 44^{m}$, $\delta = +1^{\circ}\ 20'$."

A later observation by the discoverer gives

1895 Nov. 18.0608 Greenw. M.T. $\alpha = 13^{h}\ 46^{m}\ 43^{s}.4$, $\delta = +1^{\circ}\ 9'\ 59''$. Daily motion, $+1^{m}\ 44^{s}$ in α, and 29′ southward.

COMET *c* 1895.

Elements and ephemeris of this comet have been received by telegraph from the University of California.

Prof. A. O. LEUSCHNER sends elements from first three days' observations at Mt. Hamilton, as follows:

$$T = 1895 \text{ Dec. } 18.2695 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \Omega &= 320^{\circ}\ \ 1'.4 \\ \omega &= 271\ \ 57.6 \\ i &= 141\ \ 55.0 \end{aligned}\right\} \text{Eq. } 1895.0$$

$$q = 0.19429$$

$$(\text{C}-\text{O})\quad \Delta\lambda = 5''; \quad \Delta\beta = 3''.$$

From these Mr. ROSS has computed the ephemeris for Greenwich midnight.

1895	App. α h m s	App. δ ° ′	log ρ	Brightn.
Nov. 20.5	13 52 15	−0 8	0.1691	1.3
24.5	14 2 54	−2 37		
28.5	14 16 33	−5 44		
Dec. 2.5	14 35 10	−9 49	0.0278	5.6

From Prof. CAMPBELL have also arrived the following elements, computed by himself from the Lick observations of Nov. 17, 18, 19.

$$T = 1895 \text{ Dec. } 18.41 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \omega &= 273^{\circ}\ \ 1' \\ \Omega &= 320\ \ 49 \\ i &= 141\ \ 25 \end{aligned}\right\} \text{App. eq.}$$

$$q = 0.1914$$

also an ephemeris practically identical with that above.

COMET *d* 1895.

A comet was discovered by BROOKS at Geneva, N.Y., Nov. $21^{d}\ 14^{h}$ (Washington M.T.) in the position,

$\alpha = 9^{h}\ 52^{m}$, $\delta = -17^{\circ}\ 40'$.

It is described as large, and moderately bright. Motion northward.

CORRIGENDUM.

No. 358, p. 182, Note to Star-Table. *for* $14^{m}.0$ *put* $14''.0$.

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COMET *c* 1895. ELEMENTS AND EPHEMERIS.
COMET *d* 1895.
CORRIGENDUM.

PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed November* 23.

THE
ASTRONOMICAL JOURNAL.

No. 360.

VOL. XV. BOSTON, 1895 DECEMBER 5. NO. 24

TABLES OF THE TRAJECTORY OF THE POLE, FOR COMPUTING VARIATIONS OF LATITUDE,

BY S. C. CHANDLER.

The relative motion of the earth's axes of figure and rotation is governed by a law, synthetically derived from observation, whose constants are so accurately known that we can with certainty compute, in advance, tables of the variations of latitude for any given station. Such tables are necessary for the correction of zenithal or horizontal points of meridian and vertical circles, as well as for other purposes. A convenient and suitable place for them in future would be the various astronomical ephemerides. Meanwhile the coordinates for the years 1893-1896 are here given, for the correction or comparison of current series of observations. The intervals of 20 days will permit easy interpolation. The positive axis of y is directed to Greenwich, and that of x to longitude 270°, or 90° east of Greenwich, (see *A.J.* XIV, pp. 83 and 129). The variations of latitude for a station in longitude λ, reckoned positive west from Greenwich, may be found by

$$\varphi - \varphi_0 = x \sin \lambda - y \cos \lambda$$

where φ is the instantaneous, and φ_0 the mean latitude.

1893	x	y	1894	x	y	1895	x	y	1896	x	y
	″	″		″	″		″	″		″	″
Jan. 5	−0.123	−0.098	Jan. 0	+0.007	−0.129	Jan. 15	+0.111	−0.043	Jan. 10	+0.119	+0.080
25	.118	− .031	20	− .001	.100	Feb. 4	.116	.043	30	.162	.068
Feb. 14	.104	+ .038	Feb. 9	.009	.065	24	.112	.042	Feb. 19	.191	.051
Mar. 6	.081	.100	Mar. 1	.017	− .024	Mar. 16	.095	.040	Mar. 10	.201	+ .026
26	.054	.151	21	.026	+ .014	Apr. 5	.068	.037	30	.192	− .004
Apr. 15	− .025	.185	Apr. 10	.035	.048	25	+ .032	.034	Apr. 19	.162	.037
May 5	+ .004	.199	30	.044	.075	May 15	− .010	.032	May 9	.116	.070
25	.028	.192	May 20	.052	.093	June 4	.054	.028	29	+ .056	.098
June 14	.047	.169	June 9	.059	.099	24	.095	.023	June 18	− .011	.118
July 4	.058	.131	29	.062	.097	July 14	.130	.016	July 8	.079	.130
24	.066	.081	July 19	.062	.087	Aug. 3	.154	− .007	28	.141	.128
Aug. 13	.068	+ .026	Aug. 8	.056	.070	23	.163	+ .005	Aug. 17	.189	.114
Sept. 2	.062	− .029	28	.044	.050	Sept. 12	.157	.018	Sept. 6	.220	.087
22	.057	.077	Sept. 17	.029	.028	Oct. 2	.134	.035	26	.229	.048
Oct. 12	.046	.115	Oct. 7	− .007	+ .008	22	.097	.050	Oct. 16	.215	− .005
Nov. 1	.036	.141	27	+ .020	− .010	Nov. 11	− .048	.065	Nov. 5	.178	+ .043
21	.026	.151	Nov. 16	.047	.024	Dec. 1	+ .008	.076	25	.124	.090
Dec. 11	.017	.146	Dec. 6	.073	.034	21	.066	.081	Dec. 15	− .057	.131
31	+0.007	−0.129	26	+0.095	−0.040	41	+0.119	+0.080	35	+0.019	+0.159

The basis for the construction of this table is eq. (55), *A.J.* XIV, p. 129, with the exception that, instead of the approximate values of the constants of the 428-day term there used, the values are taken exactly as defined by eq. (52), *l.c.*, p. 74; namely,

$$T_1 = 2402327 + 428.6\,\mathrm{E} + 55 \sin \Psi$$

$$r_1 = 0''.135 + 0''.050 \sin \Psi$$

where $$\Psi = (t - 2402327)\; 0^\circ.015$$

Therefore the coordinates of the table are

$$(59)\quad \begin{cases} x = r_1 \sin(t-T_1)\theta + 0''.11 \sin(\odot - 300^\circ) \\ y = r_1 \cos(t-T_1)\theta + 0''.11 \cos\odot \end{cases}$$

The longitude ⊙ is that of the fictitious or mean sun. We have for the current decade,

E	T_1	θ	r_1
		°	″
+20	2110942.1 = 1888 Oct. 31.1	0.848	0.174
21	1366.6 = 1889 Dec. 29.6	.849	.170
22	1790.6 = 1891 Feb. 26.6	.850	.166
23	2211.3 = 1892 Apr. 25.3	.850	.162
24	2637.6 = 1893 June 22.6	.851	.157
25	3060.5 = 1894 Aug. 19.5	.852	.152
26	3483.1 = 1895 Oct. 16.1	.852	.146
27	3905.7 = 1896 Dec. 11.7	.852	.141
28	4328.2 = 1898 Feb. 7.2	.852	.135
29	4750.6 = 1899 Apr. 5.6	.852	.130
+30	2115173.2 = 1900 June 2.2	0.852	0.124

The choice of the adopted constants rests on the following considerations. From a discussion, the details of which I need not print, of all the European observations by TALCOTT's method from 1889 to 1894, I have found that they independently confirm the fact that the coefficient r_1 is at present diminishing, as required by the law developed, from the observations 1825–92, in *A.J.* 322. Thus we have

	Observed	Eq. (52)
	″	″
1890.5	0.171	0.168
1893.5	0.155	0.157

Further, the comparison of data not used in deducing eq. (52) confirms also the fact that the present length of the 428-day period is about 123 days, as assigned by that equation. Again, observations more recent than those used in *A.J.* 329 fully confirm the dimensions and position of the annual ellipse there found. Through the courtesy of Profs. BECKER, DUBIAGO and RISTENPART, I have been supplied with the manuscript results of recent observations at Strassburg, Kasan and Karlsruhe. Mr. GEORGE A. HILL also has kindly sent me the series of prime-vertical observations which he has been making at the Washington Observatory since October 1894. Combining all these with Prof. DOOLITTLE's results, *A.J.* 340 and 360, I have found the elements of the annual ellipses for 1894 and 1895, in the same manner as for 1890, 1891–2 and 1893, described in *A.J.* 329. We thus have

T	L	ω	a	b
	°	°	″	″
1890 Apr. 11	20.9	44.7	0.309	0.112
1892 Apr. 1	10.6	51.4	.311	.054
1893 Mar. 27	5.4	23.4	0.289	0.082
1894 Apr. 9	17.7	68.9	0.293	0.020
1895 Apr. 9	17.2	32.1	0.359	0.029

Cambridge, 1895 Nov. 23.

The last two are relatively uncertain, being found from intervals of only 250 days each, which cover only two-thirds of the annual revolution.

It is interesting to note that the above elements, derived independently from five different revolutions, apparently show that no appreciable progressive change has taken place in the direction of the major-axis upon the earth's surface. The question of an apsidal motion, which I have suggested as possible (*A.J.* XIV, p. 84), seems therefore to be answered in the negative, so far as five years' observations enable us to judge. This important fact will be helpful in the search for the cause of this singular annual motion.

I add a table of variations of latitude for Pulkowa, Berlin, Paris and Washington, during 1896. Greenwich is not included because, for $\lambda = 0$, we have $\varphi - \varphi_0 = -y$; so that for Greenwich the variations may be taken directly from the table of y, reversing the signs.

VARIATIONS OF LATITUDE IN 1896, $\varphi - \varphi_0$

1896	Pulkowa	Berlin	Paris	Washington
	″	″	″	″
Jan. 10	−0.129	−0.105	−0.085	+0.098
30	.141	.104	.074	.143
Feb. 19	.140	.094	.059	.175
Mar. 10	.121	.072	.034	.190
30	.091	.040	− .004	.188
Apr. 19	− .050	− .001	+ .031	.166
May 9	+ .002	+ .041	.065	.129
29	.056	.082	.096	.077
June 18	.107	.117	.118	+ .016
July 8	.152	.145	.133	− .048
28	.181	.157	.134	.109
Aug. 17	.194	.155	.121	.159
Sept. 6	.186	.136	.096	.195
26	.157	.100	.057	.212
Oct. 16	.113	+ .055	+ .014	.209
Nov. 5	+ .053	− .001	− .036	.183
26	− .015	.059	.085	.141
Dec. 15	.081	.114	.129	.085
35	−0.147	−0.150	−0.160	−0.017

From the above tables it will be seen that the period of the insignificant variations which have prevailed during the last year and a half is now ended, and that we are entering upon the epoch of increasing amplitudes indicated by the law as announced three years ago (*A.J.* 277), and described in *A.J.* 307, p. 162.

RELATIVE POSITIONS OF *TETHYS* AND *DIONE*,

OBSERVED WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

By ORMOND STONE.

The following measures are a continuation of the observations of the satellites of *Saturn* given in *A.J.* 350. The angles given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction.

1894	Eastern Time	p	Eastern Time	s
	h m s	°	h m s	″
Mar. 14	13 17 11	101.10	. . .	. .
19	16 43 6	81.28	. . .	. .
21	11 59 28	318.68	12 36 45	25.60
	13 7 3	342.21	12 43 45	24.77
23	12 41 26	268.30	12 47 34	15.20
26	11 20 14	244.57	12 4 7	51.78
27	10 12 43	75.07	10 32 27	73.83
30	11 24 32	48.59	11 37 29	15.06
Apr. 6	10 7 20	254.68	10 14 26	57.32
	10 38 23	256.25	10 30 0	59.09
8	10 37 46	187.90	10 56 12	21.73
	11 19 36	205.28	. . .	. .
14	13 22 3	267.81	13 41 31	101.42
	. . .	. .	13 47 11	101.44
16	10 42 30	224.45	10 51 5	10.54
	14 55 0	252.65	10 54 18	10.27
	15 12 30	253.95	15 5 28	14.59
	. . .	. .	15 7 30	14.49
22	14 12 21	271.65	14 20 13	30.22
	14 28 35	271.05	14 22 14	30.10
27	10 30 47	181.18	10 39 40	18.39
	10 46 39	188.54	10 41 1	17.91
28	9 16 41	284.99	9 25 16	27.05
	. . .	. .	9 27 26	26.87
29	12 52 15	56.22	12 59 12	8.75
	13 3 47	58.36	13 0 11	8.83
30	12 47 36	110.76	12 53 39	32.13
	13 1 1	112.10	12 55 21	31.98
May 3	8 29 51	259.74	8 35 39	73.91
	8 42 40	260.26	8 37 29	74.37
9	9 13 39	277.71	9 20 13	71.72
	9 32 23	278.24	9 23 21	71.56
15	10 0 34	56.95	10 6 55	36.28
	10 19 8	59.83	10 10 36	36.46
16	12 38 56	37.41	12 45 36	12.47
	12 53 13	41.69	12 49 11	13.01
17	8 55 9	269.52	8 58 27	13.48
	9 2 58	267.68	9 0 21	13.28
June 3	10 24 51	58.55	10 32 5	24.41
	10 41 40	61.19	10 35 5	24.95
4	9 17 31	103.24	9 20 33	12.88
	9 25 11	102.78	9 22 45	11.88
	12 6 57	104.76	12 12 25	8.12
	12 22 8	105.72	12 14 21	7.97
14	9 50 33	332.53	10 2 53	20.89
	10 15 37	345.38	10 8 47	20.41
15	8 28 59	102.81	8 39 29	41.45
	8 48 47	103.58	8 43 51	41.18
	12 0 35	114.62	12 14 40	26.80
	12 24 49	117.20	12 17 26	26.27
22	10 17 20	22.42	10 26 40	6.01
	10 33 21	28.34	10 28 51	6.15
June 22	11 17 9	41.22	11 22 52	6.60
	11 30 29	41.16	11 25 45	6.78
1895				
Jan. 31	. . .	. .	17 34 44	35.58
Feb. 19	16 35 55	125.34	16 50 32	35.13
	16 42 0	126.85	16 55 27	34.45
	17 16 42	132.31	17 1 17	33.95
	17 22 2	132.14	17 8 12	33.29
21	15 30 1	308.42	15 44 46	9.47
	15 36 34	307.90	15 49 32	9.07
	16 10 52	309.78	15 58 9	9.36
	16 17 4	312.22	16 2 9	9.58
	16 22 33	311 14	18 36 20	9.20
	18 24 48	325.71	. . .	. .
	18 29 26	327.68	. . .	. .
Apr. 5	13 11 24	243.37	13 25 31	22.03
	13 15 51	244.55	13 30 40	22.25
	13 50 46	246.78	13 38 31	23.13
	13 57 23	246.95	13 42 11	22.88
	15 31 56	252.91	. . .	. .
10	13 57 12	85.52	14 9 50	26.30
	14 47 5	86.47	15 9 58	25.48
	14 51 18	86.43	15 16 50	25.06
11	13 31 42	274.34	13 49 37	30.46
	11 3 34	274.90	13 54 12	30.37
13	14 21 51	256.60	14 37 51	84.05
	. . .	. .	14 44 37	84.86
	. . .	. .	14 53 22	85.86
15	11 30 8	141.17	. . .	. .
17	13 3 51	345.47	13 15 31	8.69
	13 6 39	345.89	13 18 39	8.88
	13 9 12	346.11	13 22 11	8.67
	13 32 55	351.40	13 23 43	8.74
	13 34 48	351.58	. . .	. .
	13 37 10	352.33	. . .	. .
	13 40 51	352.05	. . .	. .
23	12 31 30	79.74	12 56 5	20.46
	12 35 20	79.54	13 1 31	20.90
May 4	10 22 42	120.51	10 30 44	23.95
	10 39 34	122.72	10 34 59	23.53
18	9 37 11	90.61	9 43 54	46.07
	9 55 20	91.41	9 48 59	46.03
22	9 36 36	340.79	9 48 45	17.28
	10 9 23	352.90	9 49 6	17.28
	10 13 48	354.79	9 58 27	16.75
	10 18 17	356.55	9 58 33	17.05
	12 25 25	38.51	12 38 10	20.11
	12 29 26	39.49	12 40 23	20.18
	. . .	. .	12 48 13	20.62
	. . .	. .	12 50 16	20.57
29	8 59 2	222.83	. . .	. .
	9 3 59	222.77	. . .	. .
	9 38 16	227.09	. . .	. .
	9 41 58	226.74	. . .	. .
June 2	11 32 2	321.14	. . .	. .
	11 36 55	322.50	. . .	. .
	12 8 39	331.35	. . .	. .
3	9 8 37	101.34	. . .	. .

LATITUDE-DETERMINATION AT THE SAYRE OBSERVATORY,

By C. L. DOOLITTLE.

(Continued from No. 340, page 27, of this Journal.)

$\varphi = 40° 36' 20'' +$

1894–5	I	Obs.	II	Obs.	1895	II	Obs.	III	Obs.	1895	III	Obs.	IV	Obs.
	″		″			″		″			″		″	
Dec. 23	3.30	9			April 10	3.20	10			July 9	3.03	9	2.91	10
27	3.38	10			11	3.15	10			10	3.03	9	3.12	7
28	3.29	7			14	3.14	10			16	3.11	7	2.98	10
31	3.40	10			15	3.40	3			18	2.94	9	2.98	11
Jan. 1	3.32	10			18	3.26	10			19	2.82	9	2.99	11
1	3.18	9			19	3.25	9			25	3.03	9	2.95	10
11	3.20	10			20	3.12	10			26	2.91	8	3.00	9
11	3.11	7			21	3.19	10			28	2.91	9	3.10	11
16	3.18	10			23	3.32	10			29	2.72	7	3.09	11
19	3.20	10			May 1	2.99	10			30	2.82	9		
23	3.42	10			3	3.07	9			31	2.76	9	2.98	10
24	3.33	10			6	3.20	9			Aug. 3	2.94	9		
27	3.34	10	3.27	8	9	2.99	10	3.02	9	5	2.71	7		
29	3.33	2			10			3.04	9	7	2.87	9	3.23	8
31	3.40	10	3.43	8	12	2.72	2			8	2.95	9		
Feb. 2	3.33	10	3.17	8	13	2.99	9			10	2.92	9	2.93	11
March 3	3.10	10			16	3.11	9	3.08	8	12	2.92	9		
5	3.56	7			18	3.10	10	3.24	6	13			2.98	11
6	3.09	3			22	2.79	10	3.21	9	15	2.88	9	2.95	10
9	3.12	10			23	2.87	10	3.21	9	18	2.87	9	2.97	5
10	3.21	5			28	3.23	10	3.00	9	19	2.95	8	2.99	10
14	2.95	3			29	2.92	10	3.17	9					
16			3.27	10	30	3.05	10	3.24	9					
17	3.18	8	3.27	10	June 7	2.86	10	3.09	9					
18	3.40	7	3.37	9	8	2.88	10	3.16	9					
19	3.33	8			9	2.96	10	3.01	8					
21	3.17	6	2.96	10	11	3.03	10	3.11	9					
22			3.27	9	14	3.04	9							
23	3.34	5	3.19	10	23	2.92	10	3.13	9					
28			2.86	9	28	2.66	5							
					29	2.80	3							
		216		91			267		421			172		155

	I	Obs.	II	Obs.	III	Obs.	IV	Obs.	Mean
	″		″		″		″		″
Dec. 25–Jan. 24	3.281	112	. . .	. .	. . .	. .	. . .	. .	3.281
Jan. 27–Feb. 2	3.355	32	3.240	24	. . .	. .	. . .	. .	3.322
Mar. 3–Mar. 28	3.317	72	3.171	67	. . .	. .	. . .	. .	3.244
Apr. 10–May 3	. . .	. .	3.208	101	. . .	. .	. . .	. .	3.208
May 6–May 29	. . .	. .	3.013	89	3.118	68	. . .	. .	3.066
May 30–June 29	. . .	. .	2.933	77	3.124	53	. . .	. .	3.028
July 9–July 29	. . .	. .	. . .	. .	2.947	76	3.015	90	2.981
July 30–Aug. 19	. . .	. .	. . .	. .	2.874	96	2.999	65	2.936

The interval from February 2 to March 3 was occasioned by illness on my part. This ends my latitude-series at the Sayre Observatory, but I hope soon to resume this work at the Flower Observatory of the University of Pennsylvania.

Philadelphia, Pa., 1895 *Nov.* 20.

NOTES ON VARIABLE STARS,

By JOHN M. THOME.

In No. 352 of this Journal, Prof. PAUL has recorded some observations of southern variables, and has asked me to supplement them with additional data from the original records of our DM., which I am very glad to do.

The star 5511 *RS Librae*, though not in our Vol. XVI, curiously enough turns up in the original manuscript with three observations. Its omission from the catalogue was owing to a not uncommon mistake in assuming that because a note is perfectly clear to him who makes it, it will therefore be equally far-reaching to everyone else at any future epoch. The region was first passed over 1886 May 7, at which time the star was not seen, which means that it was fainter than 10^{M}. But 1887 April 17, it was noted as $8\frac{3}{4}^{M}$. As this gave only one position, and apparently only one magnitude, a pencil line was drawn through the position to indicate that it was not to be accepted until confirmed by a revision. This occurred 1891 Aug. 29, when a note was made saying "a star here, 10th mag.," but the pencil line was not erased! The star has, therefore, this tardy justice done to it, and will hereafter appear as $-22°10973\frac{1}{2}$, the $\frac{1}{2}$ being not inappropriate under the circumstances. Our observed place was $15^{h}\ 17^{m}\ 20^{s}$, 22° 27′.7.

7255. *RT Sagittarii.*

The faint companion, of which Prof. Paul makes mention, was not noted by us, and our estimates of magnitude all refer to the star −39°13722. These were: 1890 Aug. 6, $9\frac{1}{2}^{M}$; Aug. 10, 10^{M}.

7404. *R Microscopii.*

Our estimates were: 1887 June 13, 10^{M}; July 18, $9\frac{3}{4}^{M}$.

There is still another, and, I am sorry to say, a fictitious star in the DM. catalogue to which I wish to call attention before any more time is wasted upon it. It was not intended that the place should be published, but its formidable magnitude probably carried the day when the collecting was done. It is the star −25°12601, $7^{M}.3$, $17^{h}\ 54^{m}\ 36^{s}.0$, −25° 19′.0. Nothing was seen in this place during the original zones, but on the revision, in 1891, a great "variable,—orange" appeared, and its place was at once determined from the surrounding stars. I have never seen anything there since, and am inclined to think that what I really looked at was −24°13736, which is also colored, and of the same brightness. But as we always carefully checked up our configurations, I am unable to explain how such a mistake could have happened. The only other explanation is that I saw a planet.

I regret that I have not been able to obtain new estimates for these stars, but the weather has been so outrageously bad for the past four months that we have drifted hopelessly behind in our current work. The clear skies of Cordoba seem really to be vanishing.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE DUDLEY OBSERVATORY,

By A. JAY ROY.

1895 Albany M.T.	*	No. Comp.	Planet — * $\Delta\alpha$	Planet — * $\Delta\delta$	Planet's apparent α	Planet's apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			(349) *Dembowska.*					
h m s			m s	′ ″	h m s	° ′ ″		
May 6 10 37 53	16	8	+0 36.10	+ 1 2.2	15 38 42.09	−24 2 58.8	n9.383	0.888
7 10 30 20	16	8	−0 16.74	+ 1 24.7	15 37 49.27	−24 2 36.3	n9.391	0.888
13 12 34 13	17	5	−2 46.11	+ 5 1.0	15 32 17.94	−23 58 50.4	8.782	0.907
18 11 43 3	18	5	+2 20.19	− 2 7.5	15 27 42.66	−23 53 56.9	7.556	0.908
22 12 5 46	19	6	−0 5.60	+ 3 51.7	15 24 1.84	−23 19 1.1	8.957	0.905
			(49) *Pales.*					
Aug. 30 9 1 57	20	6	−0 22.72	+10 37.5	22 55 50.58	− 2 27 2.6	n9.519	0.788
Sept. 1 10 56 0	20	6	−1 58.56	+ 3 9.5	22 54 14.78	− 2 34 30.3	n9.110	0.795
8 8 24 7	21	6	−4 2.10	− 3 56.9	22 48 52.67	− 3 1 0.3	n9.512	0.791
10 8 13 56	22	10, 8	+0 1.36	+ 1 43.4	22 47 20.12	− 3 8 58.5	n9.513	0.792

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
16	15 38 3.35	+2.64 +2.66	−24 3 44.8	−16.2	Gould 21325, Albany, 2 obs., etc.
17	15 35 1.29	+2.76	−24 3 34.6	−16.8	Gould 21248, etc.
18	15 25 19.69	+2.78	−23 51 32.0	−17.4	Gould 21028, etc.
19	15 24 4.64	+2.80	−23 52 35.3	−17.5	Gould 20997, etc.
20	22 56 9.61	+3.69 +3.71	− 2 38 0.0	+19.9 +20.2	Munich I, 31905
21	22 52 51.03	+3.74	− 2 57 23.8	+20.4	Karlsruhe, etc.
22	22 47 15.00	+3.76	− 3 11 2.1	+20.2	Karlsruhe

Star 16, adopted p.m., $-0^{s}.0094$, $-0''.022$.

COMPARISON-STARS FOR THE COMET *e* 1894 (*SWIFT*),

By R. H. TUCKER.

The stars used by Prof. Barnard, for his observations of January (*A.J.* 338), have been observed with the meridian circle.

Since these observations were the latest made of this comet, and will be especially useful for the question of identity of the orbit, the places of the stars are of importance.

Lick Observatory, Mt. Hamilton, 1895 *October* 25.

M. Equinox 1895.0 α	M. Equinox 1895.0 δ	Mag.
h m s	° ′ ″	
1 13 59.10	+7 50 35.1	8½
1 17 22.42	+8 11 19.9	8
1 18 5.16	+8 31 45.5	9½
1 20 57.85	+8 59 4.8	9

ELEMENTS AND EPHEMERIS OF COMET *c* 1895 (*PERRINE*),

By Rev. G. M. SEARLE.

I have computed the following elements of Comet *c* from the observations at Mt. Hamilton, Nov. 18.0608, that at Northfield, Nov. 22.0051, and one obtained here Nov. 27.9383; the dates are given in Greenwich M.T.

$$T = \text{Dec. } 18.2470 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned}\omega &= 271^\circ\ 27'\ 6''\\ \Omega &= 319\ 38\ 51\\ i &= 112\ 10\ 52\end{aligned}\right\}\ 1895.0$$

$$\log q = 9.291725$$

Middle place (O−C): $\Delta\lambda = +19''$. $\Delta\beta = -5''$

These elements give the following coordinate formulas:

$$\begin{aligned}x &= [9.962753]\, r \sin(v + \ \ 35^\circ\ 19'\ 13'')\\ y &= [9.997146]\, r \sin(v + 128\ 10\ 21)\\ z &= [9.616097]\, r \sin(v + 232\ 51\ 40)\end{aligned}$$

and the following ephemeris for Greenwich midnight:

Date	α	δ	log Δ	Brightn.
	h m	° ′		
Dec. 2.5	14 35.1	− 9 48	0.0268	5.7
4.5	14 47.4	−12 20	9.9987	7.8
6.5	15 2.6	−15 16	9.9701	11.2
8.5	15 21.7	−18 37	9.9425	16.4
10.5	15 46.3	−22 22	9.9182	24.8
12.5	16 17.8	−26 13	9.9014	37.5
14.5	16 56.8	−29 33	9.8981	54.4
16.5	17 39.9	−31 24	9.9137	69.5
18.5	18 18.4	−31 10	9.9479	65.9
20.5	18 45.4	−29 20	9.9908	45.5
22.5	19 0.2	−27 5	0.0318	26.9
24.5	19 9.3	−24 56	0.0673	16.0
26.5	19 15.1	−23 2	0.0974	10.0
28.5	19 19.0	−21 22	0.1231	6.7

As is evident, the comet will not be favorably seen in the northern hemisphere at the time of its greatest brightness; it will, however, probably be a conspicuous object in southern latitudes. The unit of brightness is that of the observation of Nov. 18, used for the elements.

ELEMENTS AND EPHEMERIS OF COMET *c* 1895 (*PERRINE*),

By A. O. LEUSCHNER.

The following elements and ephemeris were deduced under my direction from the first three observations secured at Mount Hamilton, Nov. 18, 19, 20 (Greenw. dates), by the students in the course of Theoretical Astronomy (E. F. Ross, F. G. Radelfinger, J. C. Ferris, J. Kuno and W. H. Wright, Fellow in Mathematics).

$$T = \text{December } 18.2695 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned}i &= 141^\circ\ 55'\ 1''\\ \Omega &= 320\ \ 1\ 22\\ \omega &= 271\ 57\ 38\end{aligned}\right\}\ \text{Mean equinox 1895.0}$$

$$\log q = 9.28845$$

$$(O-C):\quad \Delta\beta = -3''.0,\quad \Delta\lambda \cos\beta = -1''.5$$

Berkeley, Cal., 1895 *Nov.* 23.

Ephemeris for Greenwich Mean Midnight.

Date	App. α	App. δ	log ρ	Brightn.
	h m s	° ′		
Nov. 20.5	13 52 15	−0 7.6	0.1691	1.3
21.5	54 41	−0 42.3		
22.5	57 19	−1 18.5		
23.5	14 0 2	−1 56.6		
24.5	2 51	−2 36.8	.1275	
25.5	5 57	−3 19.4		
26.5	9 14	−4 4.7		
27.5	12 45	−4 52.9		
28.5	16 33	−5 44.5	.0804	
29.5	20 40	−6 39.5		
30.5	25 7	−7 38.5		
Dec. 1.5	29 56	−8 41.5		
2.5	14 35 10	−9 49.0	0.0278	5.6

OBSERVATIONS OF COMET *c* 1895 (*PERRINE*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY C. D. PERRINE AND R. G. AITKEN.

1895 Mt. Hamilton, M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 17 16 41 36	1	7	. . .	−9 34.5	. . .	+1 10 45.3	. . .	0.725
17 0 36	1	10	−0 37.06	. . .	13 46 41.80	. . .	*n*9.654	. . .
17 41 26	2	7	+0 54.90	. . .	13 46 15.08	. . .	*n*9.625	. . .
17 43 5	2	7	. . .	+5 3.8	. . .	+1 9 32.7	. . .	0.722
18 17 38 48	3	10, 9	−2 33.90	−2 41.9	13 48 55.68	+0 38 52.3	*n*9.626	0.726
19 17 17 12	4	10, 10	+0 22.92	+0 14.3	13 51 11.45	+0 7 15.1	*n*9.642	0.727
	5	10, 6	−0 51.56	−2 52.2	13 51 10.51	+0 7 14.7	. . .	. . .

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	13 47 17.00	+1.86	+1 20 36.7	−16.9	Boss, A.G. Albany 4807
2	13 45 48.31	+1.87	+1 4 45.8	−16.9	Boss, A.G. Albany 4804
3	13 51 27.70	+1.88	+0 41 51.1	−16.9	Boss, A.G. Albany 4829
4	13 50 46.64	+1.88	+0 7 17.7	−16.9	Rümker 4516, Lamont 4210
5	13 52 0.18	+1.88	+0 10 23.8	−16.9	Rümker 4524, Lamont 4218

NOTE.

The observations of Nov. 17 were made by C. D. P., the others by R. G. A.

A series of ten transits of stars 4 and 5 over the same micrometer thread, placed in the meridian, gives the difference of R.A. between the two stars as 1m 14s.60, while the differences between the mean places for 1895.0 are Rümker (1836) 1m 13s.48, Lamont (1850) 1m 13s.65. There is apparently a considerable relative proper motion between the two stars, which accounts for the large difference in the comet's apparent right-ascensions given above.

OBSERVATIONS OF COMET *c* 1895 (*PERRINE*),

MADE AT THE WASHBURN OBSERVATORY, MADISON,

BY GEORGE C. COMSTOCK.

1895 Madison M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 19 17 42 25.1	1	16, 5	+0 12.71	+2 47.0	13 51 1.37	+0 9 19.6	*n*9.582	0.777
23 17 39 36.8	2	*	+0 19.41	+3 30.7	. . .	. . .	*n*9.579	0.785
27 17 47 13.0	3	18, 4	+2 55.58	−1 37.5	14 14 33.90	−5 17 5.8	*n*9.568	0.798

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	13 50 46.75	+1.91	+0 7 19.6	−17.0	München I. Neue Annalen
2	14 1 2.0	+1.96	−2 18.8	−17.2	S.DM. −2°3783
3	14 11 36.31	+2.01	−5 15 11.2	−17.1	Arg. Gen. Cat.

* Measures of position-angle and distance.

COMET *d* 1895 (*BROOKS*).

Elements and an ephemeris for this comet were telegraphed Nov. 26 from the University of California, at Berkeley, by Prof. LEUSCHNER, who with assistance of Messrs. FERRIS and ROSS, had computed them. They were sent to Mr. RITCHIE, and immediately distributed by him in a circular of the "*Science Observer*."

ELEMENTS.

T = 1895 Oct. 21.2183 Greenw. M.T.

Ω = 83° 1′

ω = 298 59

i = 76 43

q = 0.84594

EPHEMERIS FOR GREENWICH MIDNIGHT.

1895	α	δ
	h m s	° ′
Nov. 25.5	9 39 36	− 8 23
29.5	9 21 17	+ 5 31
Dec. 3.5	8 56 33	+23 12
7.5	8 19 35	+41 29

Mr. RITCHIE has sent the following position, observed by Dr. WILSON at Northfield, Minn., and telegraphed him by Prof. PAYNE, Director.

Greenw. M.T.	α	δ
1895 Nov. 23.0152	9h 48m 30s.3	−14° 59′ 24″

OBSERVATIONS OF COMET *d* 1895 (*BROOKS*).

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY.

BY J. M. SCHAEBERLE AND R. G. AITKEN.

1895 Mt. Hamilton M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ	Obs.
			m s	′ ″	h m s	° ′ ″			
Nov. 22 16 15 18	1	6 . 6	−2 18.62	+3 36.6	9 48 8.34	−14 59 13.8	*n*9.241	0.836	S
23 16 12 12	2	14 . 3	−4 37.42	−3 32.2	9 44 53.92	−12 30 26.5	*n*9.215	0.822	A
24 14 57 4	3	12 . 10	−0 23.63	+5 33.8	9 41 36.46	− 9 56 46.3	*n*9.458	0.795	A

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	9 50 54.08	+2.88	−15 2 46.9	−3.5	$\frac{1}{3}$(2 Oeltz. Argel. 10222 + W.B. IX, 1054)
2	9 49 28.37	+2.97	−12 26 49.9	−4.4	Arg. Gen. Catal. 13493
3	9 41 57.00	+3.09	−10 2 15.3	−4.8	$\frac{1}{2}$(Paris 12026 + Arg. Gen. Catal. 13311)

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ADVERTISEMENT.

PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office at Boston, Mass., as second-class matter. *Closed December 4.*

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THE

ASTRONOMICAL JOURNAL

EDITED BY

BENJ. APTHORP GOULD

VOLUME XVI
DECEMBER 1895 TO SEPTEMBER 1896
NUMBERS 361-384

WITH TWO PLATES

BOSTON
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THE

ASTRONOMICAL JOURNAL.

No. 361.

VOL. XVI. BOSTON, 1895 DECEMBER 20. NO. 1

ON A NEW DETERMINATION OF THE CONSTANT OF NUTATION,

BY S. C. CHANDLER.

The constant of lunar nutation holds an important place among the fundamental astronomical constants which stand in need of revision. While, on the one hand, its determination is not subject to some of the difficulties which impede us in the case of the constant of aberration, due to complication with the variations of latitude of short period, and to subjective sources of error having an annual period, there are, on the other hand, sources of error to be feared from which many former determinations of it have not been entirely protected. Thus, if the angle between the pole and the zenith be subject, as there is convincing reason to believe, to slow changes, either strictly or irregularly systematic, covering long periods of years, the observed dimensions of the nutation-ellipse will be vitiated in a manner analogous to that in which the aberration is affected by the known variations of short period. Other causes, now unknown, may have a similar disturbing influence. We must, therefore, in future, place proportionately greater reliance upon determinations of the nutation of which we can say, with some confidence, that they must be free from possible errors of this sort. The most obvious and satisfactory means of obtaining this security is to base the determinations upon a very considerable number of stars distributed as uniformly as practicable over the entire sky. This condition is met as well as can be desired, so far as the northern hemisphere is concerned, by the observations with the Greenwich Mural Circles. Not only in this respect, but also by their high quality, as demonstrated in previous papers in this Journal, as well as by their great number, they provide an almost ideal basis for a precise determination of the nutation. The object of this paper is to give the results of their discussion to obtain this constant.

The investigation has been made by the aid of an appropriation for the purpose, kindly made by the Trustees of the Bache Fund of the National Academy of Sciences, to whom I desire to express my thankful acknowledgements. This has enabled me to employ the skilful service of Miss F. G. WENTWORTH, who has been engaged with me in similar work for some years, and who has become especially accomplished in this kind of computation.

The discussion rests upon 20294 observations with the Mural Circles of TROUGHTON and JONES, between 1825 April 1, and 1848 May 10. The observations from the last date to the end of 1850 were not used, — the remounting of the TROUGHTON Circle in a different location and under different conditions apparently destroying the necessary continuity and homogeneity of the series. At each culmination, every star employed was observed both directly and by reflection, and six microscopes were invariably read in each of the pair of observations. We thus have 10147 observed double-altitudes of the 34 stars, distributed as shown in Table I. For every one of these stars the observations cover practically the whole interval, which embraces nearly one and a third draconitic periods. Since the index-errors of both circles are necessarily eliminated, each of these 10147 observed declinations is independent of every other. Neither of the telescopes was shifted in its relation to its circle during the whole time in which it was used, — a circumstance of great value for a differential investigation like the present. The reduction of the observations has been fully described in *A.J.*, 313, 315, 320, and a reference to those papers will save repetition here. Since the declinations which I originally obtained, as there described, were found by the use of different provisional values of the mean latitude for the POND and AIRY series, — namely, 51° 28′ 38″.27 and 51° 28′ 38″.37, respectively, — I have now reduced them to the ultimately adopted value, 51° 28′ 38″.42, determined from the polar stars observed at both culminations as follows:

Star	Dates	φ_0	No. obs.	
			U.C.	L.C.
		$''$		
Polaris	1825–30	38.36	252	207
Polaris	1831–35	38.64	65	50
Polaris	1836–38	38.40	43	72
Polaris	1839–43	38.49	75	85
Polaris	1844–48	38.45	55	60
λ *Ursae minoris*	1840–46	38.35	10	8
δ *Ursae minoris*	1836–47	38.33	83	13
51 *H. Cephei*	1837–46	38.52	13	22
ε *Ursae minoris*	1837–47	38.55	26	12
β *Ursae minoris*	1837–46	38.18	133	19
Adopted		51° 28′ 38″.42	755	548

We thus have a series of declinations for 1830.0, homogeneously and accurately reduced, with the Pulkowa precession and nutation; the aberration-constant 20″.500; Boss's proper motions; Bessel's refraction; the mean latitude 51° 28′ 38″.42; and the reduction to the center of the instrument. These declinations were then corrected for the latitude-variation, by eq. (52), *A.J.* 322, p. 74. For the formation of the conditional equations to determine the nutation, the results were combined into ten or twelve-day groups, as described in nos. 315 and 320, pp. 17, 59. In the solutions of these equations, they were weighted strictly according to the numbers of the observations therein contained.

The equations of condition for finding the correction, Δr, to Peters's constant, (r = 9″.2235,) were taken of the form

$$x + by + c\,\Delta r \;=\; \delta - \delta_0$$

where x is the correction to an assumed mean value, δ_0, of the declination of each star; b is the interval of time, reckoned from 1825.0, as a convenient zero; y is an unknown embracing the correction to the assumed proper motion, as well as any element which may possibly affect the observations, varying with the time; and c is the coefficient of the nutation-correction, ascertained as follows:

Using only those terms of the nutation in declination which can affect the second decimal in the desired coefficient, we have, from Peters's values, for our mean date,

$$\delta' - \delta = -\,6''.8666 \cos\alpha \sin\Omega + 9''.2235 \sin\alpha \cos\Omega$$
$$-\,0''.5055 \cos\alpha \sin 2\odot + 0''.5510 \sin\alpha \cos 2\odot$$

Putting, according to the known transformation,

$$\begin{aligned} b \sin(\Omega + B) &= 6''.8666 \sin\Omega \\ b \cos(\Omega + B) &= 9''.2235 \cos\Omega \\ f \sin(2\odot + F) &= 0''.5055 \sin 2\odot \\ f \cos(2\odot + F) &= 0''.5510 \cos 2\odot \end{aligned}$$

$$\delta' - \delta \;=\; +\,b \sin[\alpha - (\Omega + B)] \quad + f \sin[\alpha - (2\odot + F)]$$

Then the nutation-coefficient may be found from $c = c_1 + c_2$, where

$$c_1 = \frac{b}{r}\sin[\alpha - (\Omega + B)]; \quad c_2 = -\,\frac{2.162 f}{r}\sin[\alpha - (2\odot + F)]$$

which may be expeditiously computed by the use of Warnstorff's tables.

Table I. Corrections to Peters's Nutation-Constant, Δr.

*	Name	Approx.		Obs.	Probable error of		Δr		Δr		Coeff.	Δr		wt.
		α	δ		1 obs.	Δr	A	A'	B	B'	of $\Delta\mu'$	C	C'	
		h	°		″	″	″	″	″	″	″	″	″	
1	*α² Androm.*	0.0	28.2	240	±0.45	±0.051	−0.057	−0.088	−0.029	−0.081	+3.1	−0.022	−0.074	38
2	*γ Pegasi*	0.1	14.2	123	.43	.073	+ .113	+ .071	+ .099	+ .052	+2.2	+ .098	+ .051	19
3	*α Cassiopeae*	0.5	55.6	204	.62	.119	− .241	− .333	− .255	− .353	+1.3	− .254	− .352	7
4	*α Urs. min.*	1.0	88.4	969	.49	.036	− .088	− .094	− .092	− .098	+0.3	− .092	− .098	77
5	*α Arietis*	1.9	22.7	225	.64	.094	+ .169	+ .124	+ .192	+ .134	+2.3	+ .191	+ .133	11
6	*α Tauri*	4.4	16.2	215	.58	.081	+ .150	+ .061	+ .084	+ .065	−4.7	+ .100	+ .081	16
7	*α Aurigae*	5.1	45.8	308	.57	.052	− .103	− .141	− .135	− .137	−3.6	− .149	− .151	37
8	*β Tauri*	5.3	28.5	179	.49	.080	− .006	− .061	− .173	− .152	−5.7	− .191	− .170	16
9	*α Orionis*	5.8	7.1	145	.54	.099	− .142	− .158	− .188	− .180	−5.3	− .172	− .164	10
10	*α² Geminor.*	7.4	32.3	258	.48	.059	− .178	− .179	− .195	− .156	−4.4	− .220	− .181	29
12	*β Geminor.*	7.6	28.4	285	.56	.060	− .018	+ .028	− .116	− .040	−3.9	− .102	− .026	27
13	*α Leonis*	10.0	12.8	213	.56	.071	+ .013	+ .028	− .066	− .025	−3.5	− .071	− .030	20
15	*α Urs. Maj.*	10.9	62.7	298	.58	.066	− .164	− .115	− .148	− .090	−2.7	− .135	− .077	23
16	*δ Leonis*	11.1	21.5	166	.52	.091	+ .117	+ .118	+ .154	+ .177	−4.1	+ .140	+ .163	12
17	*δ Urs. Maj.*	12.1	58.0	160	.46	.074	− .131	− .064	− .107	− .017	−3.4	− .117	− .027	18
18	*α Draconis*	14.0	65.2	199	.45	.062	− .218	− .180	− .300	− .262	+2.7	− .268	− .230	24
19	*α Bootis*	14.1	20.1	471	.48	.045	− .195	− .146	− .112	− .077	+3.4	− .103	− .068	49
20	*ε Bootis*	14.6	27.8	200	.49	.068	− .014	+ .018	− .014	+ .015	+0.2	− .012	+ .017	22
21	*β Urs. min.*	14.9	74.8	370	.65	.068	− .072	− .029	− .014	+ .019	+4.9	− .020	+ .013	22
22	*α Coronae B.*	15.5	27.3	280	.49	.062	+ .026	+ .079	+ .022	+ .060	+2.7	+ .022	+ .060	26
23	*α Serpentis*	15.6	7.0	193	.57	.098	+ .016	+ .018	+ .044	+ .035	+1.9	+ .058	+ .049	10
24	*α Herculis*	17.1	14.6	224	.63	.090	+ .084	+ .056	+ .116	+ .072	+4.0	+ .117	+ .073	12
25	*α Ophiuchi*	17.5	12.7	289	.53	.066	+ .121	+ .128	+ .206	+ .195	+1.5	+ .220	+ .209	23
26	*α Lyrae*	18.5	38.6	633	.51	.031	+ .037	+ .001	+ .124	+ .101	+4.0	+ .134	+ .111	86
27	*β Lyrae*	18.7	33.2	326	.51	.057	+ .025	+ .022	+ .078	+ .044	+5.3	+ .130	+ .096	30
28	*ζ Aquilae*	19.0	13.6	255	.52	.070	+ .188	+ .157	+ .116	+ .075	+5.9	+ .107	+ .066	20
29	*δ Draconis*	19.2	67.4	234	.42	.057	− .005	− .043	− .003	− .061	+5.0	− .021	− .079	31
30	*γ Aquilae*	19.6	10.2	203	.63	.088	+ .248	+ .217	+ .172	+ .081	+3.9	+ .161	+ .070	13
31	*α Aquilae*	19.7	8.4	547	.56	.063	− .031	− .039	+ .055	− .016	+5.0	+ .053	− .018	25
32	*β Aquilae*	19.8	6.0	210	.55	.075	+ .019	− .035	+ .012	− .082	+4.2	+ .021	− .073	18
33	*α Cygni*	20.6	44.7	616	.50	.041	+ .058	+ .050	− .010	− .045	+5.6	− .002	− .037	60
34	*α Cephei*	21.2	61.9	375	.53	.045	− .176	− .204	− .171	− .206	+1.4	− .159	− .194	49
35	*β Cephei*	21.4	69.8	298	.51	.051	+ .064	+ .056	+ .018	− .011	+3.0	+ .039	+ .010	38
36	*α Pegasi*	22.9	14.3	206	±0.56	±0.073	−0.072	−0.066	+0.036	−0.005	+4.3	+ .043	+0.002	19
Δr	. . . .	. .	. .	. .	. . . .	. . .	−0.0266	−0.0336	−0.0241	−0.0340	. . .	−0.0192	−0.0291	
r	. . . .	. .	. .	. .	. . . .	. . .	9.197	9.190	9.199	9.190	. . .	9.204	9 194	

TABLE II. MEAN DECLINATIONS, 1830.0, FROM GREENWICH MURAL-CIRCLE OBSERVATIONS.

*	Name	POND, 1825–35			AIRY, 1836–48		
		Epoch	Obs.	δ, 1830.0	Epoch	Obs.	δ, 1830.0
				° ′ ″			° ′ ″
1	*α Andromedae*	1829.60	195	28 9 5.90	1842.64	45	28 9 5.85
2	*γ Pegasi*	29.59	99	14 14 17.22	42.08	24	14 14 17.32
3	*α Cassiopeae*	27.81	91	55 36 13.19	43.02	113	55 36 13.49
4 *U*	*α Ursae minoris*	28.25	317	88 24 8.48	41.65	178	88 24 8.55
4 *L*	*α Ursae minoris*	27.70	257	88 24 8.47	41.35	217	88 24 8.66
5	*α Arietis*	28.93	186	22 39 16.14	41.87	39	22 39 16.00
6	*α Tauri*	28.79	181	16 9 35.90	42.36	64	16 9 35.75
7	*α Aurigae*	28.37	141	45 48 53.86	41.81	167	45 48 53.66
8	*β Tauri*	29.34	135	28 27 18.44	41.39	44	28 27 18.05
9	*α Orionis*	28.55	114	7 22 3.65	42.81	31	7 22 3.36
10	*α²Geminorum*	29.12	209	32 15 9.25	41.02	49	32 15 8.96
12	*β Geminorum*	29.28	216	28 25 44.95	41.49	69	28 25 44.66
13	*α Leonis*	28.04	141	12 47 41.06	42.38	72	12 47 40.59
15	*α Ursae Majoris*	27.68	130	62 40 0.18	42.01	168	62 40 0.23
16	*δ Leonis*	27.89	116	21 27 13.48	43.42	50	21 27 13.63
17	*δ Ursae Majoris*	27.45	74	57 58 39.76	40.37	86	57 58 39.72
18	*α Draconis*	28.37	134	65 11 25.53	41.40	65	65 11 26.09
19	*α Bootis*	28.19	288	20 4 15.95	41.71	183	20 4 15.69
20	*ε Bootis*	28.68	118	27 47 42.47	42.37	52	27 47 42.47
21	*β Ursae minoris*	29.02	191	74 51 1.14	41.32	176	74 51 1.03
22	*α Coronae*	28.29	214	27 17 30.19	42.32	66	27 17 30.20
23	*α Serpentis*	28.04	169	6 57 58.56	41.62	24	6 57 58.30
24	*α Herculis*	28.80	195	14 35 25.94	40.90	29	14 35 25.75
25	*α Ophiuchi*	28.90	219	12 41 25.61	42.76	70	12 41 25.19
26	*α Lyrae*	28.26	292	38 37 48.82	40.88	341	38 37 48.56
27	*β Lyrae*	28.66	258	33 10 13.29	42.34	68	33 10 13.23
28	*ζ Aquilae*	29.25	205	13 37 1.34	41.92	50	13 37 1.40
29	*δ Draconis*	29.51	180	67 21 45.56	41.61	54	67 21 45.56
30	*γ Aquilae*	30.65	162	10 12 17.88	43.17	41	10 12 18.16
31	*α Aquilae*	28.47	481	8 25 32.19	43.73	66	8 25 31.95
32	*β Aquilae*	30.54	164	5 59 17.77	43.04	46	5 59 17.73
33	*α Cygni*	27.32	435	44 40 35.18	42.50	181	44 40 35.38
34	*α Cephei*	29.62	206	61 52 2.66	43.00	169	61 52 2.66
35	*β Cephei*	29.51	203	69 48 56.01	42.91	95	69 48 56.27
36	*α Pegasi*	1829.07	161	14 17 32.26	41.67	45	14 17 32.05

TABLE III. PROPER MOTIONS.

*	Greenw.-Pond wt. = 13	Mad.-Airy wt. = 8	Pulk. ('85–'45) wt. = 9	Mean	*	Greenw.-Pond wt. = 13	Mad.-Airy wt. = 8	Pulk. ('85–'45) wt. = 9	Mean
	″	″	″	″		″	″	″	″
1	−0.164	−0.173	−0.158	−0.1646	20	+0.014	–	+0.025	+0.0185
2	− .018	− .022	− .017	− .0188	21	+ .005	−0.002	+ .005	+ .0031
3	− .047	− .034	− .034	− .0396	22	− .092	− .106	− .105	− .0996
4	–	–	–	–	23	+ .038	+ .043	+ .044	+ .0411
5	− .153	− .153	− .150	− .1521	24	+ .025	+ .028	+ .028	+ .0267
6	− .193	− .208	− .187	− .1952	25	− .242	− .230	− .226	− .2340
7	− .441	− .432	− .414	− .4305	26	+ .271	+ .278	+ .278	+ .2750
8	− .175	− .186	− .174	− .1776	27	− .012	− .008	.000	− .0073
9	+ .007	− .007	+ .012	+ .0038	28	− .106	− .113	− .096	− .1049
10	− .068	− .089	− .065	− .0727	29	+ .080	+ .081	+ .085	+ .0818
12	− .063	− .057	− .062	− .0611	30	− .014	− .021	+ .002	− .0111
13	− .002	− .006	+ .010	+ .0005	31	+ .358	+ .371	+ .385	+ .3696
15	− .075	− .074	− .064	− .0714	32	− .490	− .492	− .484	− .4887
16	− .134	− .151	− .136	− .1391	33	− .013	− .004	− .001	− .0070
17	+ .011	+ .010	+ .016	+ .0122	34	+ .044	+ .054	+ .057	+ .0506
18	+0.019	+0.013	+0.020	+0.0177	35	.000	+ .010	− .001	+ .0024
19	−1.999	−2.000	−1.990	−1.9966	36	−0.050	−0.040	−0.054	−0.0485

Table I gives the results of the solution of the equations so obtained, under various conditions, which will be understood by the following explanation of its contents.

Column 8, headed Δ, contained the corrections to Peters's nutation-constant from the direct solutions of the several stars. The probable errors of a single observation and of the nutation-corrections are in columns 6 and 7; and from the latter are deduced the relative weights in the last column of the table. The mean value of the nutation from this solution is 9″.197.

This result is based on the assumption that, after eliminating the terms of short period in the latitude-variation, the mean value of the latitude is the same in all years. We must now examine whether this assumption is justified by the observations. To do this we subtract the values of x, which are the corrections to the assumed declinations, from the individual residuals. Then, combining in yearly means and changing the signs to express the results in deviations of latitude, we have the column O below.

Year	Obs.	O	C
		″	″
1825	1382	−0.02	+0.02
1826	1747	− .01	− .03
1827	1196	− .06	− .07
1828	454	− .06	− .10
1829	121	− .07	− .10
1830	141	+ .02	− .07
1831	337	− .02	− .03
1832	408	− .05	+ .02
1833	433	+ .08	+ .06
1834	461	+ .12	+ .09
1835	224	+ .06	+ .10
1836	330	+ .18	+ .08
1837	222	+ .03	+ .04
1838	218	+ .16	.00
1839	285	+ .01	− .05
1840	356	− .11	− .09
1841	221	+ .12	− .10
1842	261	− .20	− .09
1843	272	.00	− .05
1844	321	− .05	− .01
1845	254	+ .21	+ .04
1846	249	+ .11	+ .08
1847	166	+ .26	+ .10
1848	82	+ .05	+ .09

There is here a pronounced systematic deviation. It is not due to accidental collocations of sign, for it appears in different groups when the stars are separated. It is not due to anomalies of refraction, since the signs are the same north and south of the zenith. It does not arise from error in the assumed nutation, because the data for every year contain stars in all right-ascensions, which would eliminate the effect even if it were much larger. It must, therefore, be due to a change in the place of the zenith, which may arise either from subjective causes or from an actual slow change in the latitude. From this series alone it would be impossible to decide between these two alternatives; but a comparison with other series leads me to conclude that the latter is the probable explanation. I have already alluded in various places to analogous phenomena brought to light in other observations. Their concurrent testimony is in favor of a long inequality in the latitude with a period of twelve years and a range of about a quarter of a second, which may be expressed by the formula

$$\varphi-\varphi_0 = -0''.12 \cos (t-1829.5)\,30^\circ$$

As well as the evidence can be briefly stated, maxima appear to have occurred in 1836, 1847 and 1860, also, less certainly, in 1873 and 1884; and minima in 1829, 1853 and 1889, and, less certainly in 1841, 1867 and 1879. The independent discussion of the above residuals from the Mural Circles gives the formula

$$\varphi-\varphi_0 = -0''.10 \cos (t-1829)\,28^\circ.8$$

Some such term as this will reconcile the anomalies found by Nyrén, Gould and Doolittle. Indeed, Thackeray has also, independently, suggested a term of twelve years as evident in the Greenwich Transit-Circle observations; and much more recently Gonnessiat has found similar indications in his ten-years' series at Lyons.

But, whatever view may be held as to the reality of such a variation, it is evident that we ought to apply a correction, in the determination of the nutation-constant, on account of this anomaly in the observations, without respect to its cause. This may be done by applying the observed corrections, O, for the several years, or the values, C, given by the formula. I have made the computation both ways, but, as the differences in the nutation-corrections are only a very few thousandths of a second in any of the stars, and are in no wise systematically different, I quote only those for the first process which are given in column Δ'. The mean value of the nutation thus obtained is 9″.190.

To ascertain the effect of errors in the assumed proper motions I have made solutions for $\Delta\nu$ in terms of y, both with the original values of the absolute terms, and also after correcting for the twelve-year term in the latitude. These results are given in columns B and B'. The mean values of the nutation are 9″.199 and 9″.190, respectively.

The two previous results correspond to Boss's values of the proper motions. By means of the coefficients of $\Delta\mu'$ in column 12 we can now substitute any other values of the proper motions and ascertain the effect on the nutation. While Boss's proper motions are undoubtedly the best system extant, we have an independent control of them. For this purpose I propose to compare the mean declinations obtained from the mural circles in this investigation with the Greenwich Five-Year Catalogue of Fundamental Stars for 1890; with the Madison Observations, 1887-92; and also the Pulkowa Catalogues of 1845 and 1885. Table II contains the mean epochs, numbers of observations, and mean declinations furnished by the mural-circle observations, separated into two periods: Pond (1825-35) and

AIRY (1836–48). Comparing these with the first two authorities above mentioned, we have the annual proper motions in declinations given under Greenwich–Pond, and Madison–Airy, in Table III; while under Pulkowa ('85–'45) we have a third set of values. All of these, it should be remarked, are independent of BOSS; for, although Pulkowa 1845 was used by him in forming his normal system, its date lies practically at the fulcrum of that system, and, consequently, it would not influence his proper motions materially. The relative weights used, in combining these three values of the proper motions to get the mean in the fifth column, were ascertained on recognized principles, from estimates of probable accidental and constant errors, numbers of observations and intervals between the dates of the catalogues.

Multiplying the differences between these new proper motions and BOSS's by the factor in column 12 (coeff. of $\Delta\mu'$) and adding to the values in columns B and B', we have the columns C and C', corresponding to these corrected proper motions. The mean values of the nutation are 9″.204 and 9″.191, respectively.

It will thus be seen that, however we treat the results, the final value of the nutation comes out within very narrow limits. Assuming the unquestioned propriety of using the corrections due to the anomaly in the latitude, and also that BOSS's and our proper motions are of equal weight, we take the mean of the results B' and C', and thus have the definitive nutation from Greenwich Mural Circles,

9″.192 ± 0.012

It remains to combine this value with all the other determinations which can be reasonably regarded as having any weight, for the purpose of indicating the best value of the constant of nutation which astronomy at present affords. A consideration of this problem has led me to the following summary.

				r	wt.	r	wt.
From	*Right-Ascensions.*			″			
	PETERS	Dorpat	Polaris	9.216	4		
	DE BALL	Pulkowa	3 close polars	9.217	7	9″.208	21
	NEWCOMB	Greenw. Trans. Circle	4 close polars	9.196	10		
From	*Declinations.*						
	LUNDAHL	Dorpat	Polaris	9.236	1		
	CHANDLER	Pulkowa	3 zenith-stars	9.210	2		
	DE BALL	Pulkowa	3 close polars	9.234	7		
	NEWCOMB	Greenw. Trans. Circle	47 stars	9.194	21	9″.200	65
	NEWCOMB	Wash. Trans. Circle	69 stars	9.204	9		
	CHANDLER	Greenw. Mural Circle	34 stars	9.192	25		
				General mean		9″.202	

Some remarks are necessary in explanation. I have entirely set aside BUSCH's and RICHARDSON's determinations; the former largely on account of uncertainty as to the effect of unknown changes in the collimation of BRADLEY's zenith-sector, which needs to be more fully investigated; the latter for various reasons pointing to its insufficiency, the principal one being connected with the looseness of the circle-clamps, which was not discovered until long after the observations were made, and which alone renders this determination unfit for use, however this difficulty is treated. The value assigned to the Pulkowa prime-vertical determination requires special comment. NYRÉN deduced from these observations 9″.246. I have found 9″.255, but have pointed out (*A.J.* XIII, 60) a source of weakness inherent in this series, as used for such a purpose. Subsequent investigation leads me to regard any result for the nutation which may be obtained from these observations, notwithstanding their high intrinsic precision, as being quite indeterminate. It is far too dependent on the assumption that, aside from the shorter periodic terms of the latitude-variation, the mean position of the pole is constant. I cannot here go into this matter in detail, but investigation has convinced me that, if the indications of a slow fluctuation in the position of the pole rendered probable by other series are real, the nutation from this series will fall between, say, 9″.18 and 9″.23. Without excluding it, I have assumed 9″.21, and given it a very low weight. On analogous grounds, the weight which the results of DEBALL's refined researches upon WAGNER's observations should have, in taking a general mean, ought to be much less than his probable errors would give. On the contrary, for similar reasons, it seems to me that the weight of NEWCOMB's determinations from the Greenwich and Washington Transit Circles has not been overestimated by him. Without going into a more detailed statement of reasons, it suffices to say that the weights above attributed to the various values have been largely controlled by considerations relating to their probable relative freedom from the influence of systematic errors. The adopted mean gives the definitive nutation from all determinations,

9″.202

Corresponding reciprocal of the *Moon's* mass is **81.80**

using 50″.36 as the luni-solar precession.

Beside the results for latitude-variation in *A.J.* 313, 315 and 320, and for the nutation-constant in the present article, it remains yet to present the discussion of the aberration-constant from POND's observations, which has long been completed and which it is hoped soon to print. In addition, the study of the declinations and proper motions derived from them has yielded some instructive conclusions, which also must be left for a subsequent article.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER AT GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY H. C. WILSON.

[Communicated by the Director, W. W. PAYNE.]

1895 Northfield M.T.	✱	No. Comp.	☄ − ✱ $\Delta\alpha$	☄ − ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			Comet *b* 1895 (Faye).					
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 11 8 25 47	1	13 , 6	+0 40.95	− 3 5.6	21 32 15.13	−5 51 41.7	9.318	0.825
			Comet *a* 1895 (Swift).					
Nov. 11 10 16 40	3	13 , 6	+0 57.07	+ 2 50.9	1 31 51.10	+3 49 57.9	8.220	0.758
20 9 36 40	1	14 , 6	−0 18.66	− 6 4.1	1 36 11.22	+4 25 55.3	6.090	0.753
			Comet *c* 1895 (Perrine).					
Nov. 21 17 51 49	6	9 , 6	+1 21.05	+ 6 9.1	13 55 58.54	−0 59 50.8	*n*9.558	0.791
18 14 56	7	1	. . .	− 0 55.4	. . .	−1 0 23.1	. . .	. . .
18 23 32	7	3	+6 41.27	. . .	13 56 1.92	. . .	. . .	. . .
25 18 4 17	8	22 , 6	+0 29.96	+ 4 11.3	14 7 36.87	−3 41 53.6	*n*9.541	0.805
27 18 5 11	9	9 , 6	−1 10.01	+ 3 1.2	14 14 38.64	−5 20 13.7	*n*9.541	0.811
Dec. 1 18 18 26	10	9 , 6	−0 1.08	+ 3 0.8	14 32 28.04	−9 14 11.3	*n*9.521	0.827
			Comet *d* 1895 (Brooks).					
Nov. 25 16 57 14	11	9 , 6	−0 57.74	+ 9 20.7	9 37 49.92	−7 0 6.4	*n*8.570	0.838
27 17 20 16	12	9 , 6	+1 49.96	− 2 10.6	9 29 18.35	−0 18 20.8	8.554	0.792

Mean Places for 1895.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 31 31.09	+3.09	− 5 48 49.5	+13.1	Micrometer comparison with 2
2	21 32 19.37	+3.09	− 5 42 15.3	+13.6	Schjellerup 8770
3	1 30 19.94	+4.09	+ 3 46 40.1	+26.9	Munich$_1$ 732, Munich$_2$ 433
4	1 36 25.76	+4.12	+ 4 31 32.8	+26.6	Micrometer comparison with 5
5	1 38 31.52	+4.12	+ 4 28 6.9	+26.6	Lalande 3179
6	13 54 35.55	+1.94	− 1 5 42.6	−17.3	Munich$_2$ 5126
7	13 49 18.69	+1.96	− 0 59 10.5	−17.2	Greenwich 10-year catalogue 2163
8	14 7 1.92	+1.99	− 3 45 47.7	−17.2	Schjellerup 5059
9	14 15 46.66	+1.99	− 5 22 58.0	−16.9	Munich$_1$ 10063
10	14 32 27.04	+2.08	− 9 16 55.5	−16.6	Schjellerup 5190
11	9 38 14.46	+3.20	− 7 9 21.4	− 5.7	Munich$_1$ 4483, Munich$_2$ 2838
12	9 27 21.93	+3.46	− 0 16 2.8	− 7.4	Munich$_1$ 4258, Munich$_2$ 2726

COMET *c* 1895.

BY REV. G. M. SEARLE.

In the elements published by me in *A.J.* 360, the value of $\sin(\lambda - L)\cot\beta$ for the second observation was exactly satisfied, and it seemed probable that the middle place could not be much better represented by a parabola, and that the discordance might be attributed to errors of observation; but on varying the ratio of the distances, it appeared that very little change was produced in the quantity above named, as an orbit resulted giving $\Delta\lambda$ and $\Delta\beta$ (O−C), +13″ and −3″, the previous ones having been +19″ and −5″. Changing the ratio proportionately, an orbit was obtained giving values 0″ and +1″; this orbit is as follows:

$$T = \text{Dec. } 18.3142 \text{ Gr. M.T.}$$

$$\left.\begin{aligned}\omega &= 272^\circ\ 29'\ 45''\\ \Omega &= 320\ \ 21\ \ \ 1\\ i &= 141\ \ 42\ \ 20\end{aligned}\right\}1895.0$$

$$\log q = 9.284423$$

The ephemeris given will not be much affected. The case seems to be rather an unusual one.

NEW ELEMENTS AND EPHEMERIS OF COMET c 1895 (*PERRINE*),

BY W. W. CAMPBELL.

The following elements of Comet c 1895 are based upon Mr. PERRINE's observations made November 17, 24, and December 1.

$$T = 1895 \text{ Dec. } 18^d.32570 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \omega &= 272^\circ\, 35'\, 38''.0 \\ \Omega &= 320\;\; 26\;\; 19.1 \\ i &= 141\;\; 39\;\; 22.6 \end{aligned}\right\} 1895.0$$

$$q = 0.192253$$

Residuals (O—C): $\cos\beta' \Delta\lambda' = -1''.9$; $\Delta\beta' = -2''.1$.

CONSTANTS FOR THE EQUATOR 1895.0

$$x = r[9.963140] \sin(\;35^\circ\, 32'\;\; 5''.2 + v)$$
$$y = r[9.996491] \sin(128\;\; 40\;\; 55.0 + v)$$
$$z = r[9.617957] \sin(234\;\; 56\;\; 12.3 + v)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1895	App. α	App. δ	log r	log Δ	Br.
	h m	° ′			
Dec. 14.5	16 55.1	—29 27	9.384	9.900	65.3
16.5	17 38.2	—31 21	9.312	9.915	84.7
1895–'96	App. α	App. δ	log r	log Δ	Br.
	h m	° ′			
Dec. 18.5	18 17.0	—31 5	9.284	9.948	82.6
20.5	18 43.7	29 14	9.322	9.991	
22.5	18 59.3	26 54	9.398	0.032	33.3
24.5	19 8.4	24 42	9.478	0.068	
26.5	19 14.0	22 45	9.550	0.098	12.2
28.5	19 17.9	21 3	9.613	0.123	
30.5	19 20.8	19 33	9.668	0.146	5.7
Jan. 1.5	19 23.1	18 13			
3.5	19 25.0	17 1	9.758	0.183	3.2
5.5	19 26.6	15 55			
7.5	19 28.1	14 54	9.829	0.213	2.0
9.5	19 29.5	13 58			
11.5	19 30.7	13 5	9.888	0.238	1.3
13.5	19 31.9	12 16			
15.5	19 33.1	11 29	9.938	0.259	1.0
17.5	19 34.2	10 42			
19.5	19 35.2	—10 1	9.981	0.277	0.7

The comet becomes an evening object on December 16. On January 11 it again becomes a morning object.

Mt. Hamilton, Cal., 1895 *December* 4.

OBSERVATIONS OF COMET c 1895 (*PERRINE*),

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1895 Cincinnati M.T.	✱	No. Comp.	☄ — ✱		☄'s apparent		log $p\Delta$	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 26 16 50 6	1	8	+1 43.32	—6 56.3	14 10 44.38	—4 21 55.3	n9.645	0.746
27 17 14 25	2	8	+2 47.35	+0 16.2	14 14 25.67	—5 15 12.1	n9.630	0.761

Mean Places for 1895.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	14 8 59.06	+2.00	—4 17 41.9	—17.1	Berlin, *Astr. Nachr.* 2580
2	14 11 36.31	+2.01	—5 15 11.2	—17.1	Gould. Gen. Catal. 19343

REMARKS ON THE ARTICLE, "RESEARCHES ON THE ORBIT γ *VIRGINIS*, BY T. J. J. SEE,"

BY MARTIN BRENDEL.

In No. 352 of this Journal Dr. SEE gives a computation of the orbit of γ *Virginis;* his results are of great interest, but may we be allowed to distrust somewhat the fitness of his manner of sifting the material of observations. Dr. SEE says in his article:

> "After an examination of all the observations, it appeared advisable to base the orbit mainly upon the work of the great standard observers. This sifting of the observational material is rendered the more necessary by the great number and miscellaneous character of the observers."

Then, for the year 1891, Dr. SEE gives his own observations made with Dr. WELLMANN's micrometer at the Observatory of Berlin, under the direction of Prof. Dr. KNORRE, whose scholar in practical astronomy he was. He does not mention the observations made by Prof. KNORRE himself, nor those made by Dr. WELLMANN at the same time with the same instrument, and published in the same volume (*Beobachtungs-Ergebnisse, der königl. Sternwarte zu Berlin*, Heft No. 6).

Prof. KNORRE is an observer so well known for the great accuracy of his observations, that this must appear strange, and his measures of double-stars made with Dr. WELLMANN's micrometer may be the exactest ever made. Dr. SEE omits these observations, and replaces them by the results of a beginner. For the observations of Professor Knorre we have:

	θ Obs.	θ Comp.	ρ Obs.	ρ Comp.	$\theta_o-\theta$	$\rho_o-\rho$	n
1891.32	333°.0	332°.6	5″.69	5″.67	+0°.4	+0″.02	10

The results of Professor Knorre are founded upon 38 measures of the angle of position, and upon 184 measures of the distance made on 10 nights; those of Dr. See upon 12 measures of the angle of position, and 24 measures of distance made on 3 nights only.

Surely the difference of the results of both observers is very small, and the elements of the orbit would not be altered, if we should replace Dr. See's measures by those of Professor Knorre. But as Dr. See himself proposes a very careful sifting of the observational material, which indeed is necessary in computing the orbits of double stars, we hope that with regard to his other very numerous and interesting publications on this subject, he may have proceeded with more objectivity.

Berlin, 1895 October.

ELEMENTS AND EPHEMERIS OF COMET *d* 1895 (BROOKS),

By A. JAY ROY.

The following elements of Comet *d* 1895 (Brooks) were derived from observations at the Lick and Northfield observatories on Nov. 22 and Nov. 25 respectively, and a rough pointing with the equatorial of the Dudley Observatory on Nov. 28.

$$T = 1895 \text{ Oct. } 21.1351 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \omega &= 298^\circ\ 58'.1 \\ \Omega &= 83\ \ \ 1.3 \\ i &= 77\ \ 15.5 \end{aligned}\right\} \text{App. Equinox.}$$

$$\log q = 9.92656$$

For middle place (C—O): $d\lambda = -1'.2$, $d\beta = -0'.5$.

Albany, N. Y., 1895 December 6.

Ephemeris for Greenwich Midnight.

1895	App. α	App. δ	log Δ
	h m s	° ′	
Dec. 11.5	7 23 28	+55 54	9.5136
13.5	6 49 4	+60 51	9.5514
15.5	6 11 30	+64 28	9.5904
17.5	5 32 31	+66 49	9.6298
19.5	4 54 50	+68 11	9.6688
21.5	4 20 47	+68 50	9.7061
23.5	3 51 9	+68 57	9.7418
25.5	3 26 24	+68 48	9.7756
27.5	3 6 17	+68 25	9.8078
29.5	2 50 5	+67 59	9.8382
31.5	2 36 53	+67 28	9.8670

OBSERVATIONS OF COMET *d* 1895 (BROOKS),

MADE AT THE DUDLEY OBSERVATORY,

By A. JAY ROY.

1895 Albany M.T.	*	No. Comp.	☄—* Δα	☄—* Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 9 8 7 16	1	1	−0 10.99	+8 52.8	7 55 55.94	+49 2 58.5	*n*9.816	0.667
9 31 1	2	6	−5 39.18	−3 51.8	7 55 10.55	+19 15 22.5	*n*9.813	0.450
10. 11 4 39	3	10	−0 32.66	+4 45.6	7 40 31.79	+52 50 55.0	*n*9.737	9.337
14 11 9 55	4	7	−1 25.62	−0 59.9	6 34 44.18	+62 44 12.5	*n*9.643	*n*0.380

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	7 56 0.39	+6.54	+48 51 17.7	−12.0	Deichmüller, Bonn, A.G. 6358
2	8 0 43.18	+6.55	+19 19 27.1	−12.8	Deichmüller, Bonn, A.G. 6401
3	7 40 57.38	+7.07	+52 46 19.7	−10.3	Rogers, Cambridge, A.G. Mass. 2952
4	6 36 0.72	+9.08	+62 45 12.4	0.0	Krueger, Helsingfors A.G. Catal.; Arg. 7133

The comparisons of the first observation were made by Prof. L. Boss.

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Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed December 19.*

THE
ASTRONOMICAL JOURNAL.

No. 362.

VOL. XVI. BOSTON, 1895 DECEMBER 31. NO. 2

DEFINITIVE DETERMINATION OF THE ORBIT OF COMET 1879 V,

By KURT LAVES.

The Comet 1879 V was discovered by A. PALISA on August 21, 1879, at Pola. The telegram issued by the Imperial Academy of Vienna read as follows: "Comet Palisa, Aug. 21, $10^h 26^m$, Pola, A.R. = 150° 35′, *Bewegung* = +94′, P.D. 40° 54′, *Bewegung* +3′; *rund, klein aber hell.*" The comet was visible from Aug. 21 to Oct. 22 of the same year, and 129 observations were secured by the different observers, all but one being European. The heliocentric arc described by the comet during this time was 78°. The telescopic appearance of the comet has been described by some of the observers, and its apparent diameter has been measured. In the following table I give their descriptions and measurements:

1879	Observer	Observatory	Description of the Comet's Appearance	Apparent Diameter	No. Obsns
Aug. 21	Palisa	Pola	rund, klein aber hell		
Aug. 26 Sept. 16	C. Bruhns	Leipzig	. . . er zeigte einen punktartigen Kern und um diesen eine koernige Verdichtung . . .	Aug. 26 2r about 2′. . .	
Sept. 6–13	Kobold	Göttingen	am 6, 7, 13 Sept. war der Comet hell und rundlich, zeigte aber nur am 13 Sept. einen deutlichen Kern		
Sept. 6-Oct. 19	Schmidt	Athen	hell, sehr gut selbst sternartig verdichtet und zeigte das meiste Nebellicht an der der Sonne zugewendeten Seite, dagegen keinen Schweif Das Kernlicht war Sept. 6 $8^{\mathrm{M}}.0$ " 9 $8^{\mathrm{M}}.5$ " 13 $8^{\mathrm{M}}.3$ " 17 $8^{\mathrm{M}}.3$ Oct. 19 $9^{\mathrm{M}}.0$	Sept. 6 $r = 1'.83$ " 9 $r = 2'.55$ " 13 $r = 2'.69$ " 17 $r = 2'.56$ Oct. 19 $r = 1'.87$	3 4 4 3 3
Sept. 13	Vogel	Potsdam	der Comet machte den Eindruck eines Sternhaufens, der an der Grenze der Auflöslichkeit steht, in der Mitte verdichtet doch ohne eigentlichen Kern		
Sept. 23	Copeland and Lohse	Dun Echt	no nucleus with power 307	r about 1′ 30″	
Oct. 19	Copeland and Lohse	Dun Echt	bright round; gradually much brighter in the middle; no nucleus		
Oct. 6	von Konkoly	O-Gyalla	bei 140-facher Vergrösserung zeigte die Mitte eine Verdichtung wie ein Sternchen pulsierend	r = 1′ 20″ (mean of 10 single obsns.)	

The spectrum of the comet has been investigated by VON KONKOLY, VOGEL, COPELAND and LOHSE. VON KONKOLY observed with VOGEL's form of the spectroscope three bands in the spectrum, one of which proved to be very indistinct. The first band was situated in the yellow-green, the second in the blue-green part of the spectrum. Besides these bands, there was visible a continuous spectrum, which according to VON KONKOLY, must be regarded as originated by the whole comet, and not only by the nucleus itself. It seems, therefore, that the reflective power of this comet was more powerful than that of most of the other telescopic comets. The determination of the wave-lengths of the three bands in the metric system gave the following mean values:

$$\text{I } 559.8\,\mu\mu \quad , \quad \text{II } 516.8\,\mu\mu \quad , \quad \text{III } 488.7\,\mu\mu\,?$$

Each value is based upon four observations; the value of III must be regarded as very uncertain on account of the faintness of this band. From a comparison of the comet's spectrum with that of hydrocarbonic gas it was found that the lines similar to those three bands would have the following wave-lengths:

I′ 557.7 $\mu\mu$, . II′ 516.6 $\mu\mu$. III′ 487.5 $\mu\mu$.

Von Konkoly concludes from the large differences between the corresponding values that the self-luminous parts of the comet are *not* analogous to hydrocarbonic gas. Copeland and Lohse made the following observations of the comet's spectrum:

Band			Sept. 23	No. Obs.	Oct. 10	No. Obs.
Band	I	Center	552.7	3	549.8	1
	II	Towards red edge	513.1	1	. . .	. .
		Center	511.0	1	512.4	4
	III	Center	468.9	3	462.1	1

Vogel has identified the same three bands, and has estimated their intensities to be respectively 6, 10 and 3.

The orbit of the comet was determined several times during the period of the comet's visibility. I have compiled the different systems into the following table:

	1	2	3	4	5
Calculator	K. Zelbr Vienna	Copeland and Lohse Dun Echt	K. Zelbr Vienna	H. Leitzmann Leipzig	K. Zelbr Vienna
Observations used	Pola, Aug. 21 " 22 " 24	Dun Echt, Aug. 26 " " 27 " " 28	Pola, Aug. 21 " 24 Lund, 24 Pola & Leipzig, Aug. 26	Pola, Aug. 21 Leipzig, 28 Leipzig, Sept. 4	Pola, Aug. 21 Leip., Dun Echt, Aug. 28 Kremsmünster, Sept. 3 Pola, Sept. 12
T	1879 Sept. 25.4683	1879 Oct. 5.21041	1879 Oct. 4.50415	1879 Oct. 4.17178	1879 Oct. 4.60015
π	178° 43′ 55″	205° 21′ 15″	201° 39′ 36″	200° 55′ 0″	202° 27′ 15.0″
☊	79 30 11	88 9 19	86 52 28	86 37 19	87 7 29.8
i	71 11 22	77 50 21	76 53 59	76 46 45	77 6 11.7
$\log q$	0.07196	9.98531	9.99891	0.001134	9.995932

Systems 3 and 5 proved to be quite good approximations to the definitive system of elements, derived in this paper, if we take in consideration the smallness of the arc from which the elements were derived. In order to compare the observations with a tolerably exact ephemeris—one of the principal requirements of the method of least-squares—I determined a new system of elements from six normal places. This system will be called I, the accentuated letters referring to the equator.

I

$$
\begin{aligned}
T &= 1879\ \text{Oct.}\ 4.661673 \\
\omega' &= 139^\circ\ 18'\ 11.81'' \\
☊' &= 82\ 14\ 37.43 \\
i' &= 79\ 19\ 30.77 \\
\pi' &= 221\ 32\ 49.24 \\
\log q &= 9.9954560
\end{aligned}
$$

By means of this system of elements the following ephemeris has been computed:

Ephemeris for 12^h Berlin Mean Time.

1879	α_0	δ_0	$\log\Delta$
	h m s	° ′ ″	
Aug. 21	10 2 16.37	+49 6 38.5	0.27564
22	9 8.95	48 59 59.9	
23	15 36.04	48 52 2.8	.26842
24	22 7.31	48 42 43.9	
25	28 42.42	48 32 0.0	.26135
26	35 20.99	48 19 47.8	
27	42 2.62	48 6 4.5	.25443
28	48 46.87	47 50 47.2	
29	55 33.32	47 33 53.3	.24771
30	11 2 21.49	47 15 20.2	
31	11 9 10.90	+46 55 5.8	0.24122
1879	α_0	δ_0	$\log\Delta$
	h m s	° ′ ″	
Sept. 1	11 16 1.07	+46 33 8.2	
2	22 51.51	46 9 25.7	0.23500
3	29 41.71	45 43 57.0	
4	36 31.18	45 16 11.6	.22911
5	43 19.43	44 47 37.3	
6	50 5.98	44 16 45.4	.22361
7	56 50.35	43 44 5.5	
8	12 3 32.11	43 9 38.0	.21851
9	10 10.81	42 33 23.9	
10	16 46.04	41 55 24.4	.21389
11	23 17.43	41 15 41.2	
12	29 44.62	40 34 16.3	.20977
13	36 7.29	39 51 12.2	
14	42 25.13	39 6 31.7	.20619
15	48 37.39	38 20 17.8	
16	54 45.29	37 32 34.1	.20319
17	13 0 47.18	36 43 24.3	
18	6 43.36	35 52 52.6	.20081
19	12 33.68	35 1 3.1	
20	18 18.03	34 8 0.5	.19906
21	23 56.33	33 13 49.3	
22	29 28.51	32 18 34.5	.19797
23	34 54.53	31 22 21.1	
24	40 14.38	30 25 14.1	.19753
25	45 28.08	29 27 18.7	
26	50 35.65	28 28 40.2	.19776
27	55 37.13	27 29 23.7	
28	14 0 32.59	26 29 34.4	.19865
29	5 22.11	25 29 17.5	
30	10 5.79	24 28 38.1	.20018
Oct. 1	14 43.71	23 27 41.3	
2	19 16.00	22 26 31.9	.20233
3	23 42.76	21 25 14.6	
4	28 4.14	20 23 53.9	0.20506
5	14 32 20.24	+19 22 34.4	

1879	α_0	δ_0	log Δ
	h m s	° ′ ″	
Oct. 6	14 36 31.24	+18 21 20.1	0.20831
7	40 37.24	17 20 15.2	
8	44 38.40	16 19 23.4	.21212
9	48 34.86	15 18 48.2	
10	52 26.77	14 18 33.1	.21639
11	56 14.26	13 18 41.1	
12	59 57.48	12 19 15.3	.22107
13	15 3 36.58	11 20 18.2	
14	7 11.70	10 21 52.4	.22612
15	10 42.97	9 24 0.0	
16	14 10.52	8 26 43.0	.23149
17	17 34.50	7 30 3.3	
18	20 55.03	6 34 2.4	.23714
19	24 12.24	5 38 41.7	
20	27 26.25	4 41 2.5	.24301
21	30 37.19	3 50 5.7	
22	33 45.18	2 56 52 3	.24910
23	36 50.33	2 4 22.8	
24	15 39 52.77	+ 1 12 37.9	0.25532

In order to compare the observations with the places derived from this ephemeris, I determined the positions of the stars of comparison for the year 1879. I am greatly indebted to my friend, Mr. A. Berberich of Berlin, for looking up for me the positions of the stars from the different catalogues. He also collected the observations from the different papers for me, since our libraries in Chicago did not furnish me the data for the work. Prof. Deichmüller of Bonn kindly communicated to me the positions of stars from the Bonn A.G. Catalogue before its publication. Of great value were the positions of great many of the stars of comparison that Mr. J. Palisa has determined with the Pola Meridian Circle in 1880 (*Astron. Nach.* 2337). I have designated these observations with "Pola Merid.;" in the same manner are some positions designated by "Koenigs. Merid.," which have been observed by Dr. Rahts. In the following table the positions of the stars are given for 1879.0; in the last column to the right are named the catalogues from which the positions were derived. It must be observed that in such cases where two or more newer determinations could be secured the positions of the stars were based on them. In order to avoid mistakes the calculations for precession were carried out in two independent ways. Starting with approximate values for 1879.0 the effect of precession was calculated by using Oppolzer's table XII of the first volume. The values thus obtained were checked by computing the effect of precession from the data belonging to the mean time between 1879 and the respective epoch of the catalogue to be used.

*	1879.0		Authority
	α	δ	
	h m s	° ′ ″	
1	9 56 25.40	+49 10 30.4	A.G. Bonn, Pola Mer.
2	10 11 55.38	49 0 19.8	A.G. Bonn, Pola Mer.
3	10 19 59.25	48 59 24.2	A.G. Bonn, Pola Mer.
4	10 20 27.36	48 29 57.8	Pola Mer.
5	10 26 14.11	48 42 0.8	Pola Mer.
6	10 29 30.33	48 20 55.4	A.G. Bonn, Pola Mer.
7	10 31 32.72	48 20 36.4	Argel. Noerd. Zonen, A.G. Bonn, Pola Mer.
8	10 32 19.44	48 24 17.4	Argel. Noerd. Zonen, A.G. Bonn
9	10 34 45.75	48 19 10.1	Pola Mer.
10	10 47 25.83	48 8 8.8	Argel. Noerd. Zonen, A.G. Bonn
11	10 50 0.42	47 50 46.6	Argel. Noerd. Zonen, A.G. Bonn, Pola Mer.
12	11 31 7.07	45 23 6.6	Lalande, Armagh$_2$, Paris, A.G. Bonn
13	11 32 22.45	45 46 39.2	Lal., Groom., Radc.$_1$, Argel. Noerd. Zo., Kam., Bruss.. Romb., A.G. Bonn
14	11 33 21.02	45 49 37.0	Lal., Groom., Radc.$_1$, Argel. Noerd Zo., Kam., Bruss., Paris, A.G. Bonn
15	11 37 53.75	45 9 40.3	Lal., Argel. Noerd. Zo., Kam., Paris, A.G. Bonn
16	11 44 15.78	44 19 57.2	W$_2$, A.G. Bonn
17	11 51 0.49	44 2 18.9	Rümker$_1$, A.G. Bonn
18	11 53 47.16	44 1 3.8	Lal., Radc.$_1$, W$_2$. Rümker$_1$. Paris. A.G. Bonn
19	11 55 58.06	43 43 1.0	Lal., W$_2$, Arm.$_1$, Radc.$_1$, Pulk., Radc.$_2$, Bruss., Romb., Harv., Paris, A.G. Bonn
20	12 0 56.55	43 19 59.9	WB$_2$, A.G. Bonn
21	12 3 10.15	43 9 20.3	Lal., W$_2$, A.G. Bonn
22	12 3 48.99	42 58 56.6	Lal., W$_2$, Rümk.$_1$, A.G. Bonn
23	12 7 56.57	42 49 47.4	Lal.. W$_2$, Kam., A.G. Bonn
24	12 12 16.56	43 41 51.5	W$_2$, A.G. Bonn
25	12 15 10.11	42 9 19.4	Lal., W$_2$, A.G. Bonn
26	12 18 40.05	42 0 14.9	Radcliffe$_1$
27	12 24 26.29	41 29 56.6	W$_2$, A.G. Bonn
28	12 29 55.18	40 21 4.3	Lal., Radcliffe$_1$. W$_2$, B.B.VI, A.G. Bonn
29	12 32 23.58	40 38 25.9	W$_2$, A.G. Bonn. Pola Mer.
30	12 32 58.08	39 58 45.5	Lal., W$_2$ A.G. Bonn
31	12 34 7.33	+40 8 47.2	W$_2$, A.G. Bonn

*	1879.0		Authority
	α	δ	
	h m s	° ′ ″	
32	12 39 15.80	+39 56 41.8	Greenwich 9 years
33	12 39 53.72	39 1 18.0	Lal.
34	12 43 56.84	39 1 38.6	Lal., W$_2$, Pola Mer.
35	12 47 50.81	38 37 50.6	Koenigsberg Mer.
36	12 48 22.49	37 38 40.0	Lal., W$_2$, Pola Mer.
37	12 49 8.88	38 26 9.9	Lal., W$_2$. Pola Mer.
38	12 55 16.04	37 37 40.4	A.G. Bonn. Pola Mer.
39	12 59 26.20	36 52 4.1	B.B. VI. Pola Mer.
40	13 9 29.37	35 14 20.8	W$_2$
41	13 9 33.44	36 5 8.9	Lal., W$_2$, Pola Mer.
42	13 10 1.91	34 49 23.5	Lal., W$_2$. Pola Mer.
43	13 20 38.04	34 18 35.2	B.B. VI
44	13 22 12.06	34 15 17.2	B.B. VI
45	13 22 9.52	33 37 34.3	Pola Mer.
46	13 22 25.94	33 12 36.4	W$_2$
47	13 23 3.59	34 17 39.1	Lal., Pola Mer.
48	13 25 39.20	33 8 18.3	Pola Mer., Leiden Mer.
49	13 31 45.03	31 37 20.9	Lal., W$_2$, Pulk., Harv., Arm.$_2$, Pola Mer.
50	13 43 2.32	30 27 50.7	W$_2$, Pola Mer.
51	13 44 25.08	29 40 59.5	B.W. XIII. 921, 922
52	13 53 31.23	27 36 26.4	Equat. Compar. with W$_2$ 13^h.1002 Orwell Park
53	13 54 26.55	28 44 57.8	Equat. Compar. with W$_2$ 13^h.1173 Orwell Park
54	14 17 48.63	22 49 23.1	W$_2$, Rümk.$_1$, Pola Mer.
55	14 19 50.00	22 30 52.3	B.W. XIV
56	14 20 44.88	21 39 32.0	W$_2$, Pola Mer.
57	14 22 30.51	21 28 4.4	B.W. XIV
58	14 29 39.29	19 44 42.4	Lal., W$_2$. Rümk.$_1$, Pola Mer.
59	14 29 50.48	19 47 5.9	Lal., W$_2$. Rümk.$_1$, Pola Mer.
60	14 31 51.70	20 19 39.7	Lal., Pola Mer.
61	14 35 16.87	19 35 28.3	Pola Mer.
62	14 35 35.70	19 27 18.4	W$_2$
63	14 36 19.70	18 24 26.1	W$_2$. Pola Mer.
64	14 37 24.35	18 35 15.7	W$_2$, Rümk.
65	14 39 35.78	17 28 38.4	Lal., Piazzi, W$_2$, Rümk., Arm.$_1$, Pulk., Pola Mer.
66	14 12 43.77	16 39 7.7	Lal., W$_2$
67	14 47 15.03	15 37 45.8	Lal., W$_2$, Rümk., Arm.$_2$, Pola Mer.
68	14 49 19.18	15 28 14.1	Lal., W$_2$, Rümk.$_1$, Pola Mer.
69	14 52 33.09	14 31 23.1	Lal., Piazzi. Rümk.$_1$, Arm.$_1$, Bruss., Pola Mer.
70	14 56 4.77	13 44 38.4	Lal., W$_2$, Pola Mer.
71	14 58 12.93	13 34 52.1	Lal., W$_2$. Pola Mer.
72	14 59 37.33	12 25 30.2	Lal., W$_2$
73	14 59 42.73	12 19 41.0	Lal., W$_2$. Glasgow$_2$
74	15 0 51.00	11 32 2.5	W$_2$, Pola Mer.
75	15 2 30.87	11 22 51.5	W$_2$
76	15 5 48.32	10 34 57.3	Lal., W$_2$. Glasgow$_1$. Pola Mer.
77	15 5 58.00	10 40 23.5	Lal., W$_2$. Santini. Glasgow$_1$. Pola Merid.
78	15 9 45.09	10 34 35.6	Lal., W$_2$, Glasgow$_1$. Arm.$_2$, Pola Merid.
79	15 11 29.61	9 49 35.4	W$_1$
80	15 11 50.74	9 21 11.4	Lamont
81	15 15 45.61	8 43 11.5	Lal., W$_2$. Santini, Schjel., M$_1$
82	15 16 39.64	7 46 32.1	W$_2$. M$_1$. Pola Merid.
83	15 21 38.57	5 17 28.4	Lamont
84	15 21 44.36	6 31 29.3	Lal., W$_2$, Rümk.$_1$. Glasgow$_1$, Romb.
85	15 22 25.17	5 58 32.6	Lal., W$_2$, M$_1$. Pola Merid.
86	15 21 27.57	5 40 43.3	Lal., W$_2$, Rümk.$_1$. M$_1$
87	15 26 45.86	4 56 36.3	Equat. Compar. with B.W. XV. 501 Dun Echt
88	15 33 58.93	+ 2 57 2.0	W$_2$, Rümk.$_1$. Schjel., Glasgow$_1$. M$_1$

The following table contains the observations of the comet. The first column gives the place of observation, the second the time of observation corrected for aberration and reduced to the meridian of Berlin. In the next two columns the corrections for parallax are contained, which have been computed anew. Then follows the apparent place of the comet, and in the last two columns the values for $\Delta\alpha \cos\delta$ and $\Delta\delta$ which follow from the comparison of the observed places with the computed places. In the final discussion of the observations all observations exceeding 20″ in $\Delta\alpha \cos\delta$ and $\Delta\delta$ were excluded. Since, out of five complete observations at Göttingen four proved to be erroneous by a large amount, all of them were rejected, the same was done with the observation of Sheffield on the same account. By the horizontal strokes in the table below are separated the observations collected in six normal places; the sign "?" is used where the star of comparison is wanting; and "—" where the observation is not complete.

	Place of Observation	Berlin Mean Time 1879	Parallax		Star	App. α	App. δ	Obs.—Cal. $\Delta\alpha \cos\delta$	Obs.—Cal. $\Delta\delta$
			s	″		h m s	° ′ ″	s	″
1	Pola	Aug. 21.42478	+0.17	+4.5	1	10 2 21.07	+49 6 47.9	−0.34	+ 2.1
2	Pola	22.35008	+ .27	+3.8	2	8 15.89	49 0 53.6	+0.59	+ 8.2
3	Pola	24.39245	+ .21	+4.3	4	21 27.69	48 43 42.2	−0.69	+14.7
4	Pola	24.39952	+ .20	+4.3	3	21 30.94	48 43 0.2	−0.37	−23.2
5	Lund	24.49739	+ .01	+4.6	?	?	?	?	?
6	Pola	25.38425	+ .23	+4.2	5	28 0.20	48 32 32.2	+0.04	−36.2
7	Pola	25.39872	+ .16	+4.4	6	28 4.80	48 32 38.2	−0.75	− 9.9
8	Pola	26.62758	− .25	+4.1	9	36 16.77	48 17 42.2	−0.43	− 4.7
9	Leipzig	26.44454	+ .45	+2.1	8	35 3.30	48 20 3.6	+0.69	− 6.2
10	Dun Echt	26.49386	+ .08	+4.7	7	35 22.63	48 19 31.7	+0.24	+ 0.7
11	Dun Echt	27.54381	+ .00	+4.8	10	42 24.51	48 5 2.7	+0.29	− 1.7
12	Dun Echt	28.66946	− .18	+4.2	11	50 0.47	47 47 47.3	+0.62	+ 7.0
13	Leipzig	28.45540	+0.10	+4.8	11	10 48 32.88	+47 51 6.9	+0.31	− 0.9
14	Dun Echt	Sept. 3.64587	−0.13	+3.9	13	11 30 45.04	+45 39 43.5	−0.08	+ 1.8
15	Rome	3.33857	+ .33	+3.6	14	28 38.39	45 48 54.1	−0.24	+ 6.1
16	Kremsmünster	3.34068	+ .29	+3.7	13	28 38.92	45 47 38.1	−0.50	− 6.5
17	Kremsmünster	4.33918	+ .23	+3.8	12	35 29.09	45 20 28.2	+0.23	−19.7
18	Leipzig	4.40784	+ .19	+4.7	15	35 57.75	45 18 47.4	+0.68	− 4.5
19	Dun Echt	4.61627	− .07	+5.0	15	37 19.82	45 13 12.2	−1.71	+12.8
20	Kremsmünster	6.32330	+ .31	+3.6	?	?	?	?	?
21	Göttingen	6.38601	+ .24	+4.3	17	49 27.08	44 18 49.1		−75.1
22	Rome	6.33552	+ .34	+3.5	16	49 2.75	44 21 24.3	−0.41	− 9.7
23	Rome	7.34148	+ .34	+3.6	19	55 49.45	43 48 56.3	+0.01	− 3.3
24	Göttingen	7.37903	+ .25	+4.4	18	51 29.11	43 48 2.5		
25	Leipzig	8.43966	+ .17	+5.0	22	12 3 11.48	43 11 17.9	+0.26	− 2.6
26	Rome	8.31430	+ .36	+3.2	21	2 20.65	43 15 56.7	−0.04	+10.2
27	Kremsmünster	8.42846	+ .19	+4.9	20	3 6.41	43 11 38.2	−0.15	− 5.8
28	Rome	9.32051	+ .35	+3.5	23	9 1.30	42 39 44.8	−0.85	+ 6.9
29	Athens	9.29167	+ .37	+3.2	24	8 51.20	43 40 35.8	+0.18	− 6.0
30	Rome	10.35740	+ .32	+3.9	25	15 52.47	42 0 20.4	−0.29	−10.9
31	Orwell Park	10.39637	+ .26	+4.2	26	16 10.33	41 58 52.5	+1.53	− 9.1
32	Krakau	11.40949	+ .19	+4.9	27	22 45.69	41 19 29.7	+0.35	+34.2
33	Rome	12.34118	+ .34	+3.7	28	28 47.33	40 40 24.1	+0.78	− 9.0
34	Leipzig	12.40521	+ .22	+4.7	29	29 11.30	40 37 58.9	+0.16	+ 8.3
35	Krakau	12.36703	+ .20	+4.5	29	28 55.32	40 39 35.2	−0.85	+ 8.1
36	Pola	12.36440	+0.29	+4.2	29	12 28 55.29	+40 39 31.9	−0.01	− 2.2
37	Dun Echt	Sept. 13.49238	+0.14	+5.1	32	12 36 7.43	+39 51 10.1	−0.01	+ 3.9
38	Rome	13.35166	+ .32	+3.8	30	35 13.53	39 57 10.1	−0.13	− 6.1
39	Athens	13.29724	+ .30	+2.6	30	34 53.35	39 59 43.4	+0.29	+ 2.8
40	Göttingen	13.37588	+ .21	+3.5	31	32 50.58	39 55 46.5		
41	Kremsmünster	13.36463	+ .23	+3.5	30	35 18.15	39 56 38.5	−0.44	− 4.8
42	Krakau	13.31951	+ .24	+3.2	30	35 2.45	39 58 38.5	+0.71	− 3.2
43	Rome	14.37363	+ .31	+4.1	34	41 40.87	39 11 47.1	+0.28	− 3.6
44	Kremsmünster	14.35724	+ .29	+4.2	34	41 33.33	39 12 32.8	−0.80	− 2.1
45	Krakau	14.31647	+ .29	+3.9	33	41 19.12	39 14 22.1	+0.08	− 3.8
46	Königsberg	14.36073	+ .23	+4.6	33	41 35.60	39 12 35.5	−0.11	+10.3
47	Orwell Park	14.40909	+ .25	+4.5	34	41 54.96	39 10 7.0	+0.83	− 6.8
48	Kremsmünster	15.34950	+ .29	+4.1	37	47 44.48	38 27 1.5	−0.37	+ 5.4
49	Königsberg	15.41296	+ .17	+5.1	35	48 8.38	38 23 58.2	−0.18	+ 1.4
50	Orwell Park	15.40517	+0.25	+4.4	37	12 48 7.46	+38 24 15.4	+1.42	− 4.0

	Place of Observation	Berlin Mean Time 1879	Parallax		Star	App. α	App. δ	Obs.—Cal.	
								Δα cos δ	Δδ
			s	″		h m s	° ′ ″	s	″
51	Leipzig	Sept. 16.38615	+0.22	+4.8	38	12 51 7.10	+37 37 42.4	+0.38	+ 3.8
52	Kremsmunster	16.35969	+ .28	+4.2	36	53 56.73	37 39 2.5	−0.13	+ 6.6
53	Krakau	16.31833	+ .29	+4.0	38	53 41.63	37 33 58.1	−0.11	−117″.8
54	Athens	17.27141	+ .29	+2.9	?	?	?	?	?
55	Krakau	17.31369	+ .29	+3.9	39	59 42.13	36 52 22.7	−0.68	+ 7.4
56	Konigsberg	17.36426	+ .23	+4.7	39	13 0 1.06	36 49 49.8	−0.15	+ 5.9
57	Rome	18.31923	+ .34	+3.3	44	5 40.62	36 1 50.0	−1.22	+ 6.8
58	Kremsmünster	18.34868	+ .28	+4.1	41	5 50.64	36 0 14.0	−1.60	+ 2.6
59	Krakau	18.31149	+0.29	+3.9	44	13 5 39.63	+36 2 14.7	+0.15	+ 9.4
60	Rome	19.33444	+0.33	+3.5	42	13 11 39.38	+35 9 28.5	+1.31	+ 0.5
61	Krakau	19.29988	+ .29	+3.8	40	11 27.21	35 11 14.0	+0.34	+ 7.5
62	Konigsberg	19.34346	+ .21	+4.5	42	11 41.57	35 8 55.7	−0.38	+ 5.3
63	Kremsmünster	20.31169	+ .29	+4.0	47	17 21.64	34 16 8.1	−1.68	+ 4.1
64	Krakau	20.31349	+ .28	+3.9	43	17 16.61	34 17 44.3	−0.35	+ 9.7
65	Orwell Park	20.38839	+ .27	+3.8	47	17 42.70	34 13 21.6	+0.03	−12.9
66	Orwell Park	20.39125	+ .26	+4.3	43	17 44.79	34 13 20.1	+0.95	− 4.7
67	Orwell Park	20.40038	+ .25	+4.5	44	17 47.23	—	+0.39	
68	Krakau	21.31149	+ .28	+4.0	46	22 55.59	33 23 41.8	−0.17	− 0.6
69	Pola	21.32859	+ .31	+3.7	45	23 1.49	33 22 50.4	+0.01	+ 5.5
70	Pola	21.33627	+ .31	+3.7	48	23 4.00	33 22 28.9	−0.05	+ 7.4
71	Rome	22.31754	+ .34	+3.4	?	?	?	?	?
72	Königsberg	22.31325	+ .25	+4.3	?	?	?	?	?
73	Kremsmünster	23.32951	+ .29	+3.9	49	33 59.77	31 31 50.3	−1.98	+14.8
74	Dun Echt	23.36383	+ .21	+4.2	49	34 12.68	31 29 45.6	−0.49	+ 6.1
75	Rome	24.31603	+ .32	+3.3	50	39 18.49	30 25 32.4	−0.17	+ 7.9
76	Orwell Park	24.38575	+ .27	+4.1	50	39 42.39	30 31 16.0	+0.43	− 7.4
77	Dun Echt	25.38739	+ .22	+4.5	51	44 55.29	29 33 30.7	−0.43	+ 3.4
78	Orwell Park	26.37606	+ .25	+4.3	53	50 0.99	28 35 17.0	+0.34	−16.7
79	Orwell Park	27.36834	+0.25	+4.3	52	13 55 1.87	+27 37 15.9	+1.19	+26.7
80	Rome	Oct. 2.28263	+0.29	+3.1	54	14 18 20.54	+22 37 17.4	+0.51	−130.2
81	Dun Echt	2.39959	+ .21	+4.6	55	18 52.07	22 32 15.0	+0.33	− 1.6
82	Rome	3.29349	+ .29	+3.3	56	22 50.72	21 37 43.7	−0.11	+12.1
83	Dun Echt	3.35488	+ .22	+4.3	57	23 7.21	21 33 47.1	+0.03	+ 2.3
84	Sheffield, U.S.	4.55710	+ .19	+4.4	60	28 23.07	20 19 40.1		
85	Rome	5.29125	+ .29	+3.3	58	31 29.81	19 35 12.5	−0.11	+12.8
86	Rome	5.29125	+ .29	+3.3	59	31 30.02	19 35 13.3	+0.09	+13.6
87	Göttingen	5.29606	+ .24	+3.9	59	28 6.22	20 0 33.8		
88	Pola	5.28400	+ .27	+3.3	61	31 27.82	19 35 35.6	−0.28	+ 9.2
89	Orwell Park	5.33438	+ .24	+4.0	62	31 41.96	19 32 10.9	+0.94	− 9.5
90	Rome	6.30946	+ .29	+3.4	63	35 45.52	18 32 57.1	−0.53	+30.4
91	Rome	6.30946	+ .29	+3.4	64	35 46.02	18 33 12.0	−0.44	+34.8
92	Dun Echt	6.35306	+ .21	+4.2	63	35 57.29	18 29 59.1	−0.21	+ 2.8
93	Rome	7.27619	+ .28	+3.2	65	39 44.64	17 33 42.7	−0.78	+11.5
94	Rome	7.29789	+ .27	+2.9	65	39 50.00	17 32 29.7	−0.66	+16.6
95	Rome	8.27644	+ .28	+3.2	66	43 47.47	16 32 47.5	−0.20	+11.0
96	Rome	8.28921	+ .27	+3.2	66	43 50.99	16 32 3.7	+0.23	+13.7
97	Rome	9.27619	+ .27	+3.2	67	47 44.95	15 31 58.3	−0.19	− 0.2
98	Rome	9.27619	+ .27	+3.2	68	47 44.56	15 32 4.6	−0.56	+ 6.1
99	Rome	9.30615	+ .28	+3.4	67	47 52.08	15 30 27.8	−0.10	+18.3
100	Rome	9.30615	+ .28	+3.4	68	47 51.21	15 30 26.1	−0.92	+16.6
101	Rome	10.27187	+ .27	+3.2	69	51 36.51	14 31 53.3	−0.55	− 1.1
102	Rome	10.28801	+ .27	+3.3	69	51 40.43	14 31 1.9	−0.38	+ 6.0
103	Orwell Park	10.32193	+0.23	+4.0	69	14 51 49.76	+14 28 49.8	+1.05	− 3.1
104	Krakau	11.29298	+0.24	+4.0	70	14 55 29.36	+13 31 21.9	+0.97	+41.3
105	Rome	11.28957	+ .27	+3.3	71	55 29.65	13 30 56.5	+0.04	+ 2.9
106	Rome	12.27371	+ .27	+3.2	72	59 9.52	12 32 33.1	−0.67	+14.3
107	Rome	12.27371	+ .27	+3.2	73	59 9.26	12 32 38.4	−0.92	+ 3.7
108	Rome	12.29249	+ .27	+3.3	72	59 13.09	12 31 18.6	−1.06	+ 6.9
109	Rome	12.29249	+ .27	+3.3	73	59 12.82	12 31 28.3	−1.51	+16.6
110	Pola	13.27743	+0.26	+3.4	74	15 2 51.14	+11 33 6.9	+0.39	+ 5.1

	Place of Observation	Berlin Mean Time 1879	Parallax		Star	App. α	App. δ	Obs.—Cal. Δα cos δ	Obs.—Cal. Δδ
			s	″		h m s	° ′ ″	s	″
111	Rome	Oct. 13.27753	+0.26	+3.3	74	15 2 50.71	11 33 5.2	−0.35	+ 3.3
112	Rome	13.27753	+ .26	+3.3	75	2 50.44	11 33 8.9	−0.62	+ 7.0
113	Rome	13.29596	+ .27	+3.4	74	2 54.77	11 32 4.5	−0.30	+ 8.2
114	Rome	13.29596	+ .27	+3.4	75	2 54.66	11 32 9.1	−0.41	+12.8
115	Rome	14.27160	+ .26	+3.3	77	6 26.84	10 33 58.0	+1.00	−51.4
116	Rome	14.27160	+ .26	+3.3	76	6 26.28	10 33 57.4	+0.50	−52.0
117	Rome	14.27160	+ .26	+3.3	78	6 26.48	10 34 4.9	+0.70	−44.5
118	Orwell Park	15.31047	+ .21	+3.9	79	10 7.10	9 34 32.3	+0.52	−12.0
119	Orwell Park	15.33095	+ .21	+3.9	80	10 11.33	9 33 20.9	+0.46	−12.5
120	Göttingen	16.29552	+ .21	+3.9	81	13 31.34	8 28 3.4		
121	Rome	17.26574	+ .25	+3.2	82	16 49.41	7 42 51.0	−0.58	− 5.1
122	Rome	17.28035	+ .25	+3.2	82	16 52.23	7 42 14.3	−0.73	+ 7.8
123	Athens	18.25175	+ .26	+3.0	84	20 9.00	6 47 18.4	+0.45	−14.8
124	Rome	19.26596	+ .25	+3.2	85	23 29.02	5 51 12.2	−0.37	− 3.2
125	Rome	19.27999	+ .25	+3.2	86	23 32.18	5 50 11.1	+0.04	−17.9
126	Dun Echt	19.32144	+ .19	+3.2	83	–	5 48 11.9	–	+ 0.1
127	Dun Echt	19.32951	+ .19	+3.2	83	23 42.26	–	+1.33	–
128	Dun Echt	20.32698	+ .19	+4.1	87	26 56.66	4 52 59.2	+0.65	− 6.8
129	Rome	22.26855	+0.24	+3.3	88	15 33 5.28	3 8 32.7	+0.27	+15.6

The weight attributed to the normal places is proportional to the number of observations collected in them. Since five of the places have nearly the same number of single observations I have given to each of them the weight 1; to one of the places I gave the weight $\frac{2}{3}$. The data relating to these normal places are

	1879	α	δ	p	Obs.—Cal. Δα	Obs.—Cal. Δδ	Obs.—Cal. $\sqrt{p}\,\Delta\alpha\cos\delta$	Obs.—Cal. $\sqrt{p}\,\Delta\delta$
		° ′ ″	° ′ ″		″	″	″	″
I	Aug. 26.0	158 0 16.08	+48 26 6.66	$\frac{2}{3}$	+0.38	+1.55	+0.20	+1.27
II	Sept. 8.5	180 53 0.62	43 9 36.15	1	−0.88	−1.85	−0.64	−1.85
III	Sept. 15.5	192 9 26.70	38 20 19.23	1	−1.60	+1.40	−1.27	+1.40
IV	Sept. 23.0	203 3 6.63	31 50 36.69	1	+2.27	+1.87	+1.93	+1.87
V	Oct. 6.0	218 36 34.34	18 52 3.09	1	−1.21	+6.75	−1.15	+6.75
VI	Oct. 15.5	227 40 43.65	9 24 1.60	1	−0.86	+1.60	−0.85	+1.60

After having computed the differential quotients according to Oppolzer's development (II, 405), the twelve equations of condition were found to be the following:

$$\begin{array}{rclllll}
9.30989 &=& n7.93462\,dT & +0.09223\,d\log q & +\ 9.71688\,d\pi' & +n9.63569\,\sin i'd\Omega' & +9.11376\,di' \\
n9.80618 &=& n8.08012 & +0.15317 & +\ 9.80145 & +n9.69945 & +8.97242 \\
n0.10380 &=& n8.07292 & +0.09661 & +\ 9.76263 & +n9.59602 & +9.30182 \\
0.28556 &=& n8.03659 & +0.00456 & +\ 9.69375 & +n9.36940 & +9.43154 \\
n0.06070 &=& n7.91631 & +9.78488 & +\ 9.51763 & +\ 8.82556 & +9.43679 \\
9.92942 &=& n7.79659 & +9.57539 & +\ 9.35621 & +\ 9.39031 & +9.31650 \\
\\
0.10228 &=& 6.68993 & +9.75896 & +\ 8.99358 & +n8.90868 & +9.65244 \\
n0.26717 &=& 7.75107 & +9.50123 & +n9.21180 & +\ 9.42630 & +9.70617 \\
0.14613 &=& 7.92182 & +9.37366 & +n9.47107 & +\ 9.63234 & +9.63353 \\
0.27184 &=& 8.02951 & +9.44691 & +n9.60944 & +\ 9.73836 & +9.50978 \\
0.82930 &=& 8.09102 & +9.76106 & +n9.71157 & +\ 9.78913 & +9.18090 \\
0.20412 &=& 8.09370 & +9.93367 & +n9.73469 & +\ 9.77727 & +8.84586
\end{array}$$

In order to make these equations homogeneous I introduced the following new variables:

$x = 8.09370\,dT$, $y = 0.15317\,d\log q$, $z = 9.80415\,d\pi'$, $t = 9.78913\sin i'd\Omega'$, $u = 9.70617\,di'$, $r = 6''.75$

by this the above equations were transformed into the following:

$$\begin{array}{rclllll}
8.48059 &=& n9.84092\,x & +9.93906\,y & +\ 9.91273\,z & +n9.84656\,t & +9.40756\,u \\
n8.97688 &=& n9.98612 & +0.00000 & +\ 9.99730 & +n9.91032 & +9.26625 \\
n9.27450 &=& n9.97922 & +9.91344 & +\ 9.95848 & +n9.80689 & +9.59565 \\
9.45626 &=& n9.94289 & +9.85139 & +\ 9.88960 & +n9.58027 & +9.72537 \\
n9.23140 &=& n9.82261 & +9.63171 & +\ 9.71348 & +\ 9.03643 & +9.73062 \\
9.10012 &=& n9.70289 & +9.42222 & +\ 9.55206 & +\ 9.60118 & +9.61033
\end{array}$$

$$
\begin{array}{rcllllll}
9.27298 & = & 8.59623 & +9.60579 & +\ 9.18943 & +n9.11955 & +9.94627 \\
n9.43787 & = & 9.65737 & +9.34806 & +n9.40765 & +\ 9.63717 & +0.00000 \\
9.31683 & = & 9.82812 & +9.22019 & +n9.66692 & +\ 9.84321 & +9.92736 \\
9.44254 & = & 9.93581 & +9.29374 & +n9.80529 & +\ 9.91923 & +9.80361 \\
0.00000 & = & 9.99732 & +9.60789 & +n9.90742 & +\ 0.00000 & +9.47473 \\
9.37182 & = & 0.00000 & +9.78050 & +n9.93054 & +\ 9.98814 & +9.13969
\end{array}
$$

The solution of these twelve equations by means of the method of least squares gave for the original unknown quantities the following values:

$$
\begin{aligned}
dt &= +0.000\,535 \\
d\log q &= +0.000\,0073 \\
d\pi' &= +1''.50 \\
d\Omega' &= +3''.63 \\
di' &= -2''.45
\end{aligned}
$$

The new system of elements followed from this.

$$
\begin{array}{rcll}
 & & \text{II} & \text{Probable errors} \\
T & = & 1879\ \text{Oct. } 4.662\,208 & \pm 0.000\,381 \\
 & & ^{\circ}\quad{}'\quad{}'' & \\
\omega' & = & 139\ 18\ \ 9.68 \left.\vphantom{\begin{matrix}1\\1\\1\end{matrix}}\right\} \text{Eq. } 1879.0 & \\
\Omega' & = & 82\ 14\ 41.06 & \pm 0''.69 \\
i' & = & 79\ 19\ 28.32 & \pm 0''.43 \\
\pi' & = & 221\ 32\ 50.71 & \pm 2''.30 \\
\log q & = & 9.995\,4633 & \pm 0.000\,0009
\end{array}
$$

Referring Ω', i', ω', π' to the Ecliptic of 1879.0 we obtain

$$
\begin{array}{rcll}
\omega & = & 115^{\circ}\ 26'\ 23''.22 & \\
\Omega & = & 87\ \ 10\ \ 57.84 & \Big\} \text{Ecliptic } 1879.0 \\
i & = & 77\ \ \ 7\ \ 52.04 & \\
\pi & = & 202\ \ 37\ \ 21.06 &
\end{array}
$$

The University of Chicago, 1895 November.

The six normal places were computed with the new system of elements. When compared with the observed places the residuals proved to have the following values:

	$\Delta\alpha\cos\delta$	$\Delta\delta$
I	$-2''.66$	$+2''.04$
II	-0.48	-2.38
III	-0.64	$+0.10$
IV	$+2.39$	-0.27
V	-1.39	$+3.42$
VI	-1.51	-2.19

Instead of ten changes in the sign that might be expected there are seven. The representation of the declinations is very satisfactory; from the residuals in the right ascension might perhaps be suspected an effect of eccentricity. But, since the numbers are small, and furthermore the inclination of the orbit is 77°, a new discussion leading to a determination of the eccentricity was regarded as fruitless. The orbit of the comet may therefore be regarded as adequately represented by the above parabola.

NEW ASTEROIDS.

Through the courtesy of Prof. KREUTZ, information has been received concerning three small planets, all supposed at first to be new. One was discovered by CHARLOIS Dec. 9, and by WOLF Dec. 11.

CE 11^{M} Dec. 9, $9^{h}\,16^{m}.0$ Nice M.T. $\alpha = 4^{h}\,24^{m}\,28^{s}$. $\delta = +18^{\circ}\,57'$. Daily motion, -60^{s} in α, and $5'$ southward.

CF, $11^{M}.6$ and *CG*, $12^{M}.0$, both found by WOLF, Dec. 11, have proved to be respectively (352) and (175) *Andromache*.

NEW VARIABLE STARS.

The daily papers have announced a so-called new star in *Centaurus*, found upon the photographs taken in Peru for the Observatory of Harvard College. The position for 1900.0, published in the *Boston Herald* by Prof. E. C. PICKERING, is $\alpha = 13^{h}\,34^{m}.3$. $\delta = -31^{\circ}\,8'$ and the photographs show it as $7^{M}.2$ on two plates, and $10^{M}.9$ on another, while it is not found on plates taken between 1889 and 1895.

The star precedes No. 5253 of DREYER's New General Catalogue by $1^{s}.28$ at $23''$ S. This gives for 1875.0

$$\alpha = 13^{h}\,32^{m}\,49^{s}.9 \quad . \quad \delta = -31^{\circ}\,0'.6$$

It is clearly $-31^{\circ}10536$ of THOME's Cordoba *Durchmusterung*, there given as

$$\alpha = 13^{h}\,32^{m}\,49^{s}.6 \quad . \quad \delta = -31^{\circ}\,0'.3 \qquad 9^{M}.5$$

A similar announcement from the same Observatory states that the star DM. 17°4367, $20^{h}\,31^{m}\,4^{s}.0$, $-17^{\circ}\,46'.6$ (1855.0), $9^{M}.1$, has been found by Prof. ARTHUR SEARLE to be a variable of the *Algol*-type, varying from 9^{M} to 11^{M} or below. The period is about $4^{d}\,19^{h}\,12^{m}$; and an approximate minimum was observed by Prof. SEARLE 1895 Dec. 12, $10^{h}\,12^{m}$, Greenw. M.T.

CORRIGENDUM.

No. 359, p. 191, Ephemeris, in dates for *U Coronae* in January, *for* 6 and 13 *put* 5 and 12.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed December 28.*

THE

ASTRONOMICAL JOURNAL.

No. 363.

VOL. XVI. BOSTON, 1896 JANUARY 9. NO. 3

RESEARCHES ON THE ORBIT OF F.70 *OPHIUCHI*, AND ON A PERIODIC PERTURBATION IN THE MOTION OF THE SYSTEM ARISING FROM THE ACTION OF AN UNSEEN BODY,

By T. J. J. See.

While engaged recently in the observation of double stars at the Leander McCormick Observatory of the University of Virginia, I took occasion to measure F.70 *Ophiuchi* on three good nights (*A.J.* 349). On comparing the results with Schur's ephemeris, four months later, I noticed with surprise that the observed angle was over four degrees in advance of the theoretical place. As the Virginia measures had been made under favorable conditions and with extreme care, it became evident that even the orbit to which Professor Schur had devoted so much attention would need revision. Accordingly, after all the observations had been collected from original sources and tabulated in chronological order, I proceeded to investigate the orbit in the usual manner, and obtained a set of elements very similar to those which Burnham has given in *Astronomy and Astrophysics* for June, 1893. On comparing the computed with the observed places there appeared to be a sensible irregularity in the angular motion; and as the observed places were admittedly exact to a very high degree, it was impossible to attribute such large and continued deviations to errors of observation. It was also observed that the sign of $\theta_o - \theta_c$ showed a peculiar periodicity; the residuals being for many years steadily of one sign, and then as uniformly of the other. After making some unsuccessful efforts to correct the apparent orbit, from which the elements had been derived by the method of Klinkerfues, I decided to project the orbit found by Schur, so as to compare his apparent ellipse directly with the places given by the mean observations for each year. Though I was aware that Schur's orbit had been based wholly on angles of position, I was not a little surprised to find that the distances had been vitiated in the remarkable periodic manner indicated by the pointed ellipse in the accompanying diagram. And since I had uniformly adhered to the use of both angles and distances in deriving the orbits of double stars, it was not allowable to violate the distances as Professor Schur had done, nor could we pass over such remarkable periodic errors in the residuals of the angles. We were thus confronted with a case in which it was apparently impossible to satisfy both angles and distances. A closer examination of the diagram suggested the idea of a periodic perturbation, alternately in angle and then in distance; and the drawing, in conjunction with the computations, enabled me to see that the case is one worthy of special attention. After some delay (*A.J.* 358) the additional observations placed at my disposal by Professors Hough and Comstock, in conjunction with the independent measures made at Madison by Mr. Moulton and myself (*A.J.* 359) confirmed the correctness of the Virginia measures, and left no doubt of the rapid deviation of the companion from Schur's orbit. Before considering the physical cause of this unexpected phenomenon, I desire to remark that, in the preparation of this paper, Mr. Eric Doolittle, C. E., recently an instructor in Lehigh University, and now a student in Physical Astronomy at this University, has rendered me valuable assistance. He has carried out the calculations entrusted to him, not only with care and accuracy, but also with zeal and enthusiasm, and has, therefore, contributed in no small degree to the early completion of this investigation.

Since Sir William Herschel's discovery of the system F.70 *Ophiuchi*, 1779 August 7, the companion has described considerably more than one revolution. More orbits have been computed for this binary than for any other in the northern sky, but, in spite of the immense labor which astronomers have bestowed upon this star, the motion has proved to be so refractory and so anomalous that the companion has departed from every orbit heretofore obtained. It follows from the phenomena disclosed in this paper that the system contains a dark body, and that no satisfactory orbit can be obtained until this disturbing cause is taken into account. The following list of the orbits found by previous investigators will be of interest to astronomers; in most cases the data have been taken from original sources, but in a few instances I have relied upon the table of elements compiled by Gore in his useful "Catalogue of Binary Stars for which Orbits have been Computed."

P	T	e	a	Ω	i	λ	Authority	Source
			″	°		°		
73.862	1806.88	0.430	4.3284	147.2	46.42	125.37	Encke	
79.091	1804.155	0.34737	5.554	128.15	64.2	259.4	Encke, 1830	B.J., 1832, p. 295
80.34	1807.06	0.4667	4.392	137.03	48.1	145.77	Herschel, 1833	Mem. R.A.S., vol. V, p. 217
80.64	1806.746	0.47715	4.3159	133.8	42.87	287.23	Mädler, 1835	
96.033	1812.73	0.4438	5.316	126.9	64.61	279.8	Mädler, 1842	A.N. 444
87.52	1807.60	0.482	4.675	128.55	51.5	293.3	Jacob	
88.18	1807.48	0.4973	–	122.23	47.33	294.1	Hind, 1849	M.N., IX, p. 145
92.338	1810.671	0.4445	4.966	127.35	61.05	212.97	Villarceau, 1851	C.R., XXXII, p. 51
98.146	1806.92	0.546	4.48	141.7	49.93	187.5	Powell, 1855	M.N., XV, p. 42
93.10	1808.12	0.4894		124.53	55.27	159.53	Jacob, 1857	A.N., 1082
95.966	1808.27	0.4935	4.731	123.13	57.35	160.53	Klinkerfues, 1858	A.N., 1135
94.37	1808.79	0.49149	4.704	125.4	57.9	155.7	Schur, 1868	A.N., 1682
92.77	1807.9	0.3859	4.88	122.0	62.0	163.0	Flammarion, 1874	C.R., LXXXIX, p. 1248
94.93	1809.64	0.47286	4.770	127.37	60.0	149.72	Tisserand, 1876	Flam. *Cat. Ét. Doub.*, p. 166
94.44	1808.90	0.4672	4.790	127.38	58.08	151.92	Pritchard, 1878	Oxf. Obs., I, p. 63
87.84	1807.65	0.4912	4.50	120.08	58.47	171.75	Gore, 1888	M.N., XLVIII, No. 5
88.04	1895.28	0.4994	4.45	120.8	57.0	174.92	Mann, 1890	Sid. Mes., Nov. 1890
88.3954	1808.0707	0.4751	4.60	121.31	60.08	168.3	Schur, 1893	A.N. 3220–21
87.75	1895.6	0.50	4.56	123.5	58.3	190.8	Burnham, 1893	Astron. and Astroph., June, 1893
87.70	1895.58	0.500	4.548	125.7	58.42	198.25	See, 1895	Unpublished

An inspection of this table discloses the fact that the early investigations, so far as they are reliable, led to periods sensibly less than 90 years, while the determinations made between 1845 and 1880, or, when the companion was describing the apastron of the real ellipse, favored a period of at least 94 years. Thus Tisserand and Pritchard, so lately as 1876 and 1878, find periods of 94.93 and 94.44 years, respectively. In 1868 Schur obtained a period of 94.37 years, and similar periods before and since have been deduced by other trustworthy computers.

There is thus unmistakable evidence of a retardation in the motion of the companion near apastron; more recently this inequality has become an acceleration. It was observed by Gore in 1888 that the old orbits did not represent recent measures satisfactorily, and, accordingly, he derived a new set of elements with a period of 87.84 years, which was substantially confirmed by subsequent work of Mann and Burnham. Finally Professor Schur made an exhaustive investigation of all the observations up to 1893, and adjusted his orbit by the method of least squares to about 400 mean observations of position-angle. He says that in this work he could not advantageously employ the measures of distance, owing to the differences of the individual observers. The angles, however, were admitted to be admirably adapted to a fine determination of the elements, and, accordingly, Professor Schur's able discussion of 400 observations inspired the belief that his orbit would give good places of the companion for a great many years, if not for an almost indefinite period. But this just expectation has not been realized, owing to the action of an unseen body which disturbs the elliptical motion of the companion. To establish the existence and general character of the perturbations thus disclosed we submit the following considerations:

(1) A reference to Professor Schur's able and exhaustive paper in the *Astronomische Nachrichten*, no. 3220, 21, will enable the reader to judge of the improbability of an orbit based on such a multitude of good measures proving to be defective within two years of its completion, unless disturbing causes were at work to produce the sudden acceleration in angular motion. It is inconceivable that this rapid deviation could take place without a true physical cause. The error in the angle now amounts to about five degrees.

(2) In regard to the older observations we may remark, as Professor Schur and others before him have done, that Sir William Herschel's angles are open to some uncertainty, owing to a possible error in the reading or in the records; so that his observations do not give an exact or trustworthy criterion for the period. Herschel says, however, explicitly, that on "Oct. 7, 1779, the stars were exactly in the parallel, the following star being the largest;" and, as it does not seem that any sensible error could affect the angle which he has thus recorded, we see from the measures in 1872–3 that the resulting period would be approximately 92 years. This is an additional indication that the period of this star is not constant. A careful examination of the other early measures shows that the first really good position is that of Struve in 1825. These measures are so uniform and consistent, and appear in every way so worthy of entire confidence, that I quote the record from the *Mensurae Micrometricae* in full:

t	θ_0	ρ_0	
	°	″	
1825.42	150.1	3.89	
1825.43	147.0	4.05	4.6
1825.44	149.1	3.94	
1825.48	148.8	4.05	

	t	θ_o	ρ_o		
		°	″		
	1825.50	146.4	4.21		
	1825.60	148.1	3.90		
	1825.60	149.5	3.85		
	1825.61	149.3	4.05		
	1825.62	146.8	3.92		
	1825.63	147.3	3.85		
	1825.63	148.4	3.99		
	1825.64	147.0	4.01		
	1825.66	148.5	4.01	4 . 6	
	1825.71	148.8	4.02		
Mean	1825.56	148.2	3.98	14*n*	STRUVE

An examination of these separate measures clearly indicates that the error in the mean result does not surpass 0°.5 in angle, and 0″.1 in distance. By SCHUR's orbit the angle is corrected two degrees, and when the radius vector is thus thrown forward to 146°.2 the computed and observed distances are nearly identical. As STRUVE took special pains to secure good measures on a large number of nights, and obtained the foregoing beautiful and consistent results, we may regard his mean position as one of the highest precision. The probable error of such measures would evidently be very small.

(3) We see from the diagram illustrating the apparent ellipse that SCHUR's orbit falls within the positions given by the measures prior to 1845; so that nearly all the observations of STRUVE, BESSEL, DAWES, MÄDLER, etc., require a sensible negative correction in distance. In figure *B* the differences $\rho_o - \rho_c$ of the individual measures used by SCHUR are plotted to scale, and a glance at the figure will show the improbability of such classic observers as STRUVE, BESSEL and DAWES making the constant errors here indicated. It would be still more remarkable if the observers between 1845 and 1870 have as uniformly erred in the opposite direction. How has it happened that from 1825 to 1845 the distances were steadily overmeasured by the best observers, while during the next period the distances were constantly undermeasured? Individual observers have what may be called a personal equation (though this is far from constant and is difficult to determine with any certainty) but it could not happen that all the best observers would err alike, although in opposite directions, during the two periods. Professor SCHUR's corrections are evidently inadmissible.

(4) The peculiar periodic manner in which SCHUR's apparent ellipse crosses and re-crosses the general path which best represents the mean positions, first suggested to my mind the hypothesis of a disturbing body. Figure *C* is based upon these mean positions, and a comparison with the curve in *B* shows that the mean positions are typical of all the observations for any given year. Since I was desirous of avoiding any possible prejudice of the material used, I have retained, without alteration, the mean positions which had been formed in August before suspecting the existence of a disturbing influence.

(5) We suggest that the companion of F.70 *Ophiuchi* is attended by a dark satellite, and that the visible companion, therefore, moves in a sinuous curve about the common center of gravity of the new system, with a period somewhat less than 40 years, and in a retrograde direction. As SCHUR's orbit is based on a least-square adjustment of all the observations extending over two entire revolutions of the invisible body, it may reasonably be inferred that his apparent ellipse will represent very nearly the true motion of the center of gravity, while the apparent ellipse which best represents the observed distances will give a general outline of the path of the visible star in its sinuous motion. Let us recur to the diagram of the apparent ellipse and imagine that the visible companion and the center of gravity are in the tangent to the ellipse at the epoch of intersection in 1818. Then, the motion of the visible star being retrograde, we perceive that it will gain steadily on the center of gravity, and, in 1836, the two will be in line with the original position, after half a sidereal revolution; from 1836 to 1845 the satellite will make another quarter revolution, and again the bright companion will be in the tangent to the apparent ellipse and in advance of the common center of gravity. As the visible star will now steadily fall behind in its retrograde motion about the center of gravity, it is clear that from 1845 to 1872, which is three-fourths of a revolution, the motion of the bright body *will appear to be abnormally slow*. This is the apparent retardation previously mentioned as giving rise to the long periods found by computers who used observations extending over the apastron portion of the real orbit. Assuming that the motion is undisturbed, and hence that the areas are constant, Professor SCHUR was compelled to run his ellipse further out in this part of the orbit in order to represent the observed angles. From the diagram we see that the retrograde motion of the visible star continues after 1872, and, as this apparently accelerates the visible motion of the companion relative to the central star, SCHUR's ellipse is drawn inside of most of the observations of this period. The falling of the measured distances beyond SCHUR's orbit shows plainly the periodic motion of the visible star in accordance with the above theory. From this sketch of the effects of the disturbing body it is evident that, at the time SCHUR completed his orbit, the visible star and the unseen body were nearly in line with the central star. And since the visible companion in 1825, according to STRUVE, had an angle of 148°.2, whereas SCHUR makes it 146°.2, or, substantially the same as the center of gravity at that epoch, it follows that our hypothesis, making SCHUR's orbit represent the motion of the center of gravity, is indeed very nearly correct. Any slight correction that may be required for the periastron of SCHUR's ellipse in order to make it

represent the true path of the center of gravity, had better be deferred until additional observations disclose more clearly the nature and extent of the perturbations.

(6) We may fix the approximate elements of the visible companion about the center of gravity as follows: From 1818 to 1890, or 72 years, is the time required for two revolutions, as explained in the preceding paragraph, and hence we see that *the period is approximately thirty-six years.* The motion is retrograde, and, from the diagram of the apparent orbit, we may conclude that the distance of the visible star from the common center of gravity is about 0″.3. It is natural to suppose that the plane of the orbit is not greatly inclined to that found by Schur, but existing data will not fix all the elements with the desired precision. Perhaps until the path of the center of gravity is known with great accuracy, the simple hypothesis of a circular orbit, with node and inclination identical with the similar elements of the visible pair, will be sufficient to explain phenomena, and it follows that *both angles and distances are well represented by this hypothesis.*

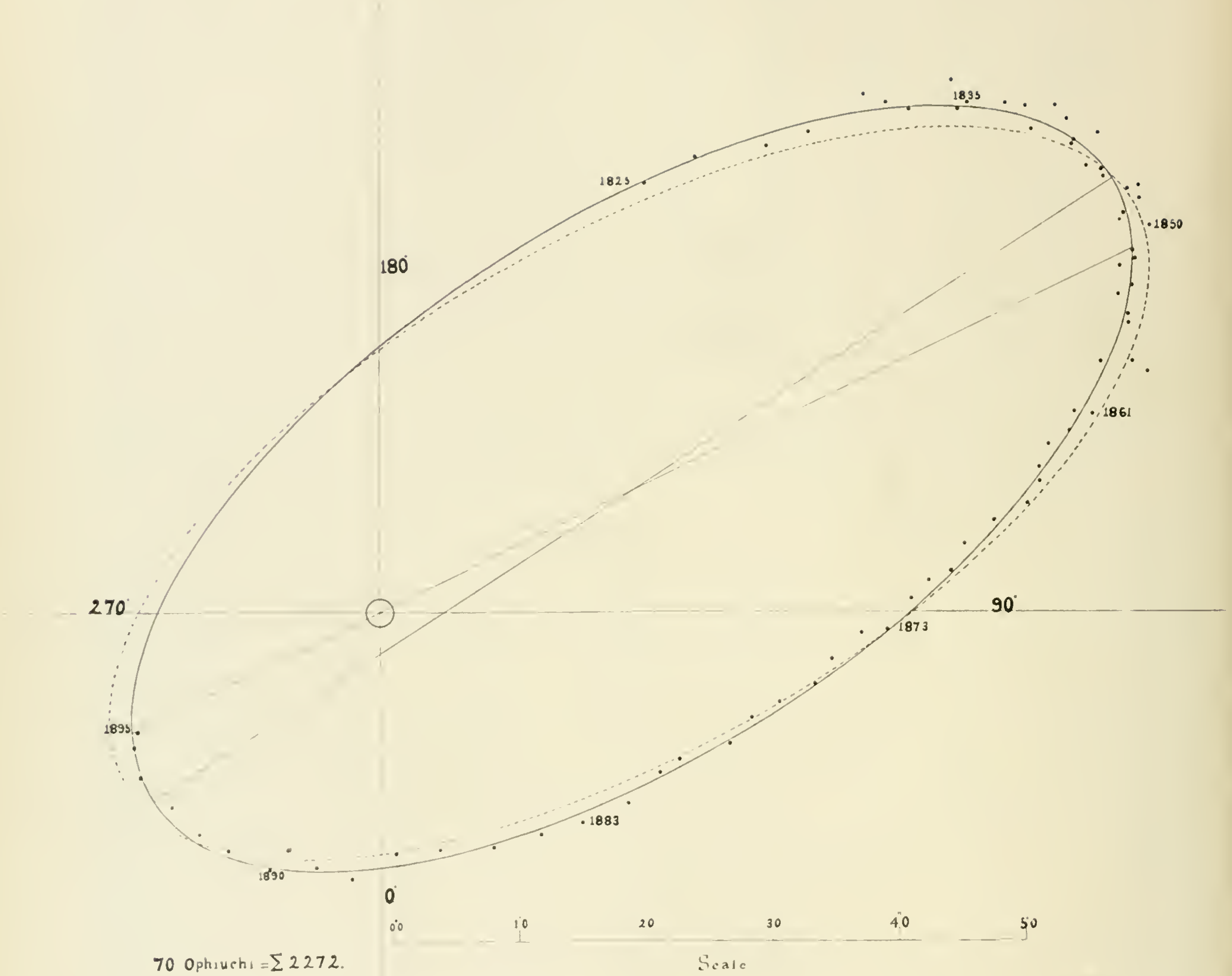
(7) As Professor Schur has given a very complete list of measures for F.70 *Ophiuchi*, I shall in this paper content myself with adding such observations as have been made since the publication of his results in 1893 (*A.N.* 3220-21.)

	°	″		
1893.47	313.8	2.22	3*n*	Maw
1893.58	313.4	2.41	3*n*	Tucker
1893.62	312.5	2.34	5*n*	Comstock
1893.62	313.6	2.27	4*n*	Schur
1893.69	309.2	2.22	1*n*	H. C. Wilson
1893.70	312.3	2.21	11*n*	Schiaparelli
1894.54	307.4	2.29	3*n*	Maw
1894.59	304.6	2.38	12–11*n*	Knorre
1894.75	302.5	2.30	4*n*	Comstock
1894.77	303.2	2.21	6*n*	Schiaparelli
1894.79	302.5	2.33	5*n*	Bigourdan
1895.32	298.6	2.22	3*n*	See
1895.58	296.9	2.26	4*n*	Maw
1895.60	296.5	2.19	3*n*	Comstock
1895.62	295.0	2.24	5*n*	Hough
1895.70	296.0	2.01	5*n*	See
1895.72	296.3	2.01	3–1*n*	Moulton

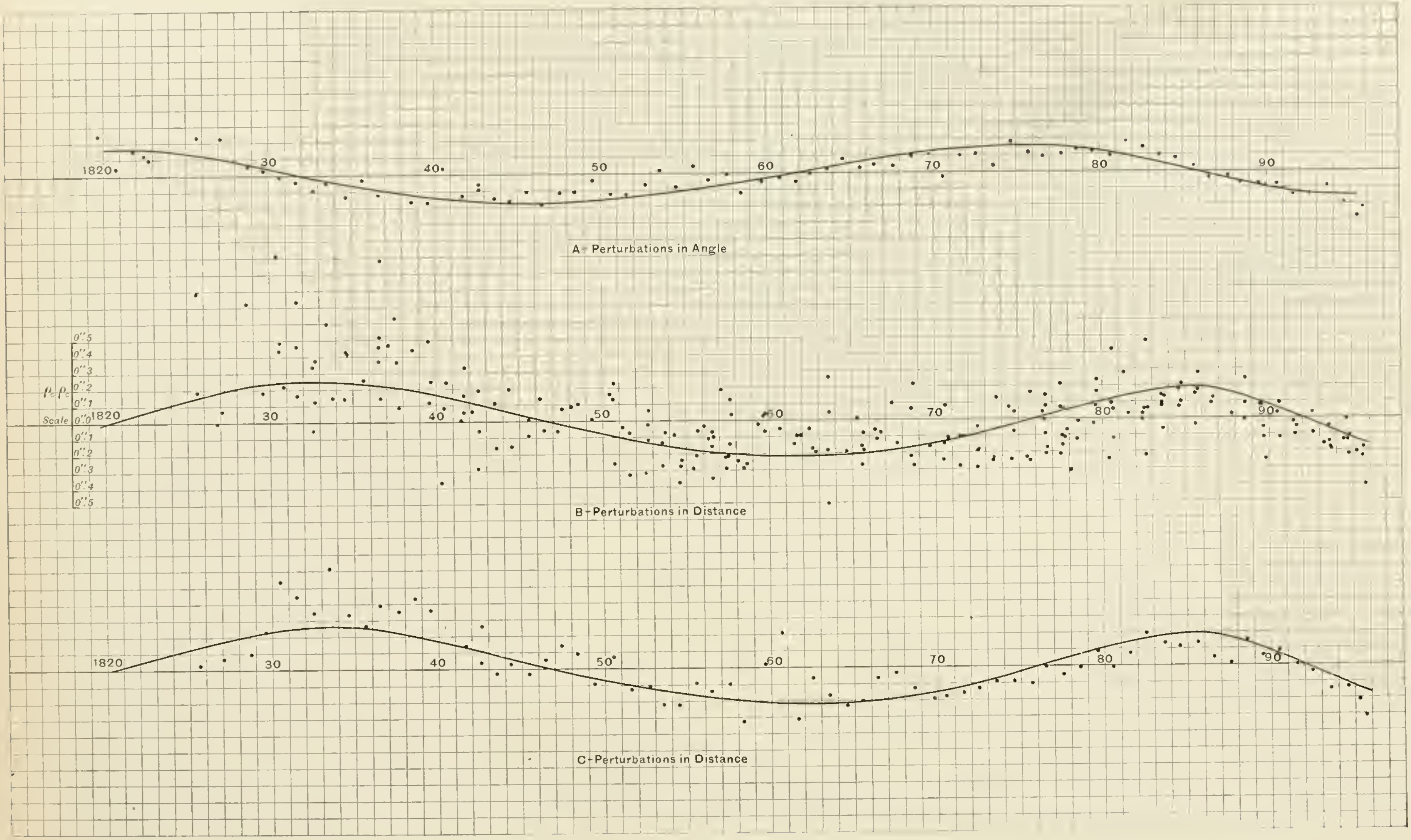
In the following table we have compared Schur's elements with the mean positions for each year; the residuals are given in the columns headed $\theta_0-\theta_1$ and $\rho_0-\rho_1$. It is at once evident that the angles are beautifully represented down to 1893, after which the error in angle rapidly accumulates until it now amounts to nearly *five degrees!* The errors in distance are illustrated in diagram *C*, which shows the same general features as diagram *B*, where the points represent the individual measures employed by Schur.

Comparison of Computed with Observed Places According to the Two Sets of Elements.

t	θ_0	ρ_0	$\theta_0-\theta_1$	$\rho_0-\rho_1$	$\theta_0-\theta_2$	$\rho_0-\rho_2$	$\alpha\theta''$	n	Observers
	°	″	°	″	°	″	°		
1779.77	90.0	–	−8.8	–	−8.11	–	−0.708	1	Herschel
1781.74	99.2	4.49	+1.6	−0.27	+4.40	−0.11	+0.359	1–2	Herschel
1802.34	336.1	–	+1.4	–	+0.71	–	+0.027	1	Herschel
1804.42	318.8		−0.3		−3.15	–	−0.128	2	Herschel
1819.64	168.5	–	−0.9	–	+5.08	–	−0.214	5	Struve
1820.77	160.2	–	−2.7	–	+0.78	–	+0.042	2	Struve
1821.74	157.6	–	−0.8	–	+2.65	–	+0.154	5	Struve
1822.42	154.8	4.27	−0.8	+1.12	+2.04	+0.72	+0.126	2	Herschel and South
1822.64	153.9	–	−1.0		+1.75	–	+0.109	3	Struve
1825.56	148.2	3.98	+2.0	+0.03	+3.17	−0.37	+0.238	28–14	South, 14–0; Struve, 14
1827.02	145.1	4.37	+2.1	+0.07	+2.82	−0.28	+0.227	2	Struve
1828.71	140.2	4.78	+0.3	+0.10	+0.72	−0.22	+0.062	4	Struve
1829.59	138.1	5.08	−0.3	+0.23	+0.39	−0.15	+0.035	6	Struve
1830.57	136.8	5.58	0.0	+0.54	−0.02	+0.24	−0.002	27	H. 9; Be. 10; Da. 6; Σ. 2
1831.58	135.1	5.68	−0.3	+0.45	−0.38	+0.36	−0.036	20–18	H. 8–6; Be. 7; Σ. 5
1832.62	133.4	5.75	−0.6	+0.35	−0.84	+0.08	−0.083	8	Da. 3; Be. 5
1833.42	132.8	6.14	−0.2	+0.61	−0.34	+0.34	−0.034	1	Dawes
1834.55	130.8	6.04	−0.8	+0.34	−1.25	+0.12	−0.128	18	Σ. 4; Da. 7; Be. 7
1835.60	130.7	6.11	+0.2	+0.26	−0.22	+0.07	−0.023	5	Struve
1836.52	128.9	6.34	−0.5	+0.38	−1.08	+0.20	−0.115	25	Mä. 8; Ek. 4; Be. 5; Σ. 8
1837.64	127.9	6.45	−0.4	+0.35	−0.96	+0.21	−0.104	27	Da. 3; Ek. 4; Be. 16; Σ. 4
1838.59	126.6	6.64	−0.7	+0.43	−1.38	+0.32	−0.152	7	Galle
1839.58	125.5	6.66	−0.9	+0.36	−1.51	+0.25	−0.169	4	Galle, 2; Dawes, 2
1840.47	126.5	6.38	+1.0	0.00	+0.33	−0.09	+0.037	14+	Ka. —; OΣ. 10; Da. 4
1841.64	124.0	6.60	−0.5	+0.14	−1.13	+0.10	−0.129	26	Mä. 8; Ka. 5; Da. 4; Be. and Schl. 7
1842.57	123.8	6.57	+0.1	+0.04	−0.50	−0.01	−0.057	35	OΣ. 8; Mä. 3; Da. 2; Ka. 22
1842.60	123.5	6.79	−0.1	+0.26	−0.78	+0.20	−0.090	20	Schlüter
1843.55	122.1	6.57	−0.7	−0.02	−1.26	−0.06	−0.146	20–19	Da. 1–0; Ek. 3; Mä. 16
1844.44	121.3	6.66	−0.7	+0.03	−1.36	+0.01	−0.158	10	Ek. 5; Mä. 5



70 Ophiuchi = Σ 2272.



A – Perturbations in Angle

B – Perturbations in Distance

C – Perturbations in Distance

t	θ_o	ρ_o	$\theta_o-\theta_1$	$\rho_o-\rho_1$	$\theta_o-\theta_2$	$\rho_o-\rho_2$	$d\theta''$	n	Observers
	°	″	°	″	°	″	°		
1845.48	120.9	6.64	−0.3	−0.03	−0.86	−0.03	−0.101	30	Hind, 9; OΣ. 5; Mä. 16
1846.46	119.3	6.76	−0.7	+0.06	−1.63	+0.07	−0.190	18+	Ja. 1; Hind, 7; Dur. Obs. —; Mä. 10
1847.47	119.1	6.85	−0.3	+0.14	−0.96	+0.16	−0.112	13+	OΣ. 4; Dur. Obs. —; Mit. 1; Mä. 8
1848.38	118.4	6.81	−0.3	+0.09	−0.96	+0.13	−0.112	9	Da. 3; Mä. 4; Bond, 2
1849.39	118.1	6.64	+0.3	−0.09	−0.31	−0.03	−0.036	5	O. Struve
1850.55	116.4	6.78	−0.5	+0.07	−1.01	+0.13	−0.118	18	Rad. 8; W. & J. 2; Mä. 4; Flt. 4
1851.54	115.5	6.57	−0.5	−0.13	−1.04	−0.04	−0.121	24	Mä. 4; Flt. 8; OΣ. 5; Mä. 7
1852.69	114.9	6.56	−0.2	−0.11	−0.63	0.00	−0.073	37	Flt. 6; OΣ. 5; Mä. 11; Ja. 15
1853.57	114.9	6.42	+0.6	−0.22	+0.12	−0.11	+0.014	21–12	Po. 9–0; Dem. 6; Da. 6
1854.48	113.2	6.37	−0.3	−0.22	−0.71	−0.11	−0.081	57–54	Ja. 21; Ja. 2; OΣ. 6; Dem. 12; Mä. 10; Da. 3; Po. 3–0
1855.52	113.3	6.45	+0.6	−0.09	+0.35	+0.01	+0.039	20–13	Lu. 2; Sr. 3; Winn. 1; Mä. 5; Da. 2; Po. 7–0
1856.43	111.7	6.34	+0.1	−0.14	−0.41	0.00	−0.046	32	OΣ. 5; Ja. 7: Mä. 3; Winn. 8; Sec. 3; Dem. 6
1857.52	111.0	6.31	+0.2	−0.10	−0.04	+0.05	−0.005	20	Ja. 3; Winn. 1; Sec. 4; Da. 2; Dem. 4; Mä. 2: OΣ. 4
1858.39	109.1	6.01	−0.9	−0.32	−1.07	−0.16	−0.116	18	Ja. 3; Mo. 2; Dem. 4; Mä. 9
1859.66	108.4	6.24	−0.4	+0.02	−0.45	+0.18	−0.048	20	OΣ. 5; Da. 4; Au. 5; Po. 5; Mä. 1
1860.70	107.3	6.33	−0.4	+0.21	−0.29	+0.40	−0.030	8+	Sec. 3; Lu. —; Au. 5
1861.67	106.2	5.70	−0.5	−0.31	−0.50	−0.14	−0.052	17	Rad. 1; Mä. 7; Au. 6: Po. 3
1862.59	105.6	5.83	−0.2	−0.07	−0.02	+0.09	−0.002	19	OΣ. 3; Winn. 1; Dem. 9; Mä. 6
1863.51	104.8	5.62	0.0	−0.17	+0.19	+0.01	+0.019	29	Aah. 11; Sec. 2; Dem. 9: Ta. 1; Fer. 1; Hl. 5
1864.54	104.1	5.43	+0.5	−0.23	+0.84	−0.06	+0.082	13	En. 2; Dem. 11
1865.50	102.4	5.32	0.0	−0.20	+0.22	−0.03	+0.021	43	En. 8; Sec. 4; Dem. 9; Ta. 2; Ka. 20
1866.43	101.2	5.31	0.0	−0.07	+0.48	+0.11	+0.044	25	Dem. 8; OΣ. 5: Ta. 5: Harv. 4; Sec. 3
1867.50	99.6	5.18	−0.2	−0.03	+0.43	+0.14	+0.038	14–13	Rad. 1; Kn. 2; Ta. 1–0; Dem. 7; Harv. 3
1868.65	98.6	4.90	+0.5	−0.13	+1.26	+0.05	+0.101	22	Dem. 7; Kn. 2; Rad. 2; Du. 4; OΣ. 2; Brw. 5
1869.80	96.7	4.64	+0.4	−0.19	+1.32	−0.03	+0.109	11	Du. 3; Dem. 8
1870.51	94.2	4.52	−1.0	−0.18	−0.40	−0.08	−0.032	12	Gl. 2; Dem. 8; Ta. 2
1871.56	93.4	4.34	+0.1	−0.16	+1.27	−0.03	+0.099	22	W.&S.2; Rad.2; Pei.2; Dem.8; Ta.1; Kn.3; Gl.3; Du.1
1872.51	91.6	4.20	+0.2	−0.13	+1.41	−0.01	+0.105	23	Brw. 2; Fer. 3; Rad. 2; Dem. 9; W. & S. 3; OΣ. 4
1873.56	88.1	4.01	−0.1	−0.09	+0.43	0.00	+0.031	14	Gl. 1; Dem. 8: W. & S. 1; Ta. 1; Rad. 3
1874.61	87.7	3.81	+1.1	−0.09	+2.71	+0.01	+0.183	17	Rad. 4; Dem. 8; Ta. 1; OΣ. 3; Gl. 1
1875.61	84.2	3.59	+0.1	−0.10	+1.74	−0.04	+0.113	21	Dem. 9; Sch. 8; Rad. 4
1876.57	80.7	3.48	−0.6	0.00	+1.53	+0.07	+0.093	31	Schur,5; Dk.2; Dem.7: Pl.3; Sch.6; Hl.3; Jed.4; Wdo.1
1877.60	77.4	3.23	−0.5	−0.05	+1.83	+0.02	+0.104	50	Dem.8; Dk.2; Hl.4; Jed.10: Pl.8; Sch.10; Cin.4; Schur,4
1878.58	74.3	3.05	+0.1	−0.01	+2.49	+0.03	+0.134	18	Dem. 7; Sea. 3; Dk. 4; Gold. 4
1879.57	69.5	2.95	−0.4	+0.09	+2.28	+0.12	+0.115	47	Cin. 18; Sch. 10; Hl. 5; Cin. 5; Sea. 4; Jed. 5
1880.59	64.0	2.64	−0.9	−0.01	+1.98	−0.01	+0.093	33	Dk. 3: Fr. 6; Hl. 6: Sch. 10; Jed. 6; Sea. 2
1881.56	60.3	2.55	+1.0	+0.08	+3.91	+0.06	+0.172	11	Dk. 2; Hl. 5; Big. 2; Sea. 2
1882.60	52.5	2.48	+0.2	+0.20	+3.35	+0.16	+0.137	30	H.C.W. 1: Dk. 2; Hl. 7; Sch. 9; Jed. 4; Sea. 3: En. 4
1883.62	44.0	2.31	−0.3	+0.18	+2.42	+0.11	+0.094	45	Per. 4; Harv. 8; Sch. 15; Jed. 6; Kü. 3; Sea. 3; En. 6
1884.56	36.0	2.17	+0.3	+0.16	+2.01	+0.07	+0.077	31–29	H.C.W. 1; Pr. 1; Per. 6: Hl. 7; Sch. 8; En. 5; Sea. 3–1
1885.61	25.9	2.06	+0.1	+0.13	+0.72	+0.02	+0.026	30–28	Per. 4; Sea. 4–2; Hl. 7; En. 8; Sch. 2; Jed. 5
1886.61	14.3	1.93	−0.9	+0.04	−0.89	−0.07	−0.031	46–44	Hl. 7; Per. 7; Jed. 7: Sch. 14; En. 7: Sm. 4–2
1887.68	3.8	1.91	−0.1	+0.01	−1.03	−0.09	−0.036	29–28	Sm. 1–0; Hl. 6; Sch. 18; Tar. 4 [Tar. 6
1888.62	353.9	2.11	−0.4	+0.15	−2.10	+0.07	−0.075	36–35	Com. 3; Maw, 4; Hl. 6; Giac. 3; Sch. 10–9; Lv. 1: Cop. 3;
1889.53	345.9	2.08	+0.6	+0.06	−2.26	−0.01	−0.082	37–34	β. 2; Hod. 2–0; Com. 5: Hl. 6; Maw, 5; Sch. 17–16
1890.57	336.7	2.21	+0.6	+0.08	−2.38	+0.04	−0.090	46	Glas. 2; Giac. 8; Hl. 7; Maw, 3; Well. 1; Big. 16; Sch. 9
1891.59	327.4	2.23	−0.6	0.00	−3.58	−0.02	−0.141	33	Maw, 4: Hl. 6; Knr. 6: Sch. 6: See 2; Big. 9
1892.52	320.8	2.26	−0.4	−0.04	−3.52	−0.05	−0.142	34	β. 4; Col. 1; Maw, 3; Com. 4; Big. 5; Sch. 17
1893.62	312.9	2.25	−0.8	−0.15	−2.30	−0.10	−0.094	19–20	Maw, 3: Com. 5; H.C.W. 0–1; Sch. 11
1894.69	304.2	2.30	−2.7	−0.14	−4.80	−0.03	−0.195	30–29	Maw, 3; Knr. 12–11; Com. 4: Sch. 6; Big. 5
1895.32	298.6	2.22	−4.3	−0.21	−6.98	−0.09	−0.280	3	See
1895.64	296.1	2.14	−4.8	−0.28	−5.62	−0.12	−0.221	20–18	Maw, 4: Com. 3; Ho. 5: See 5; Moulton, 3–1

The elements of the orbit which best represents the observed distances are as follows:

$P = 88.3954$ years } Schur's values
$T = 1808.0707$ }
$e = 0.500$

$a = 4''.548$
$\Omega = 125^\circ.7$
$i = 58^\circ.42$
$\lambda = 198^\circ.25$
$n = -4^\circ.0728$

Apparent orbit:

Length of major axis	= 9″.00
Length of minor axis	= 1″.17
Angle of major axis	= 122°.9
Angle of periastron	= 295°.8
Distance of star from center	= 2″.198

The values of P and T are taken from SCHUR's orbit, because the values of these elements derived from so many observations may be regarded as very nearly the mean of all the periods and epochs which result from the observations prior to 1893. The residuals which follow from the use of these elements are given in the columns marked $\theta_0 - \theta_2$ and $\rho_0 - \rho_2$. In case of the second elements the periodic errors in angle are very noticeable, but, as the simple differences $\theta_0 - \theta_2$ would not be strictly comparable at different distances, we have reduced all these angular displacements to seconds of the arc of a great circle by the formula

$$\frac{r''(\theta_0 - \theta_2)^\circ}{57^\circ.3} = d\theta''$$

where r'' denotes the apparent length of the radius vector in seconds of arc, and $(\theta_0 - \theta_2)^\circ$ the residuals of position-angle expressed in degrees. The displacement $d\theta''$ is tabulated and also illustrated graphically in diagram *A*. It will be seen that the maximum or minimum displacement in angle is practically identical in time with the zero of the curves of distance in *B* and *C*; and that the zero of the curve of angles corresponds to the maximum or minimum of the curve of distances. This displacement of phase would be a necessary consequence of the orbital motion of the visible companion about the common center of gravity, and may be said to establish completely the reality of that phenomenon. The present theory does not require the several phases of the curves to be of equal length, since the tangent to the ellipse itself revolves very unequally in different parts of the orbit, and the zero of the curve of distance, for example, depends on the coincidence of this tangent with the line connecting the bright with the dark body.

(8) The problem here presented of finding the elements of the orbit of the visible companion from irregularities in the elliptical motion is very much more difficult than those arising from the irregular proper motions of perturbed stars, such as *Sirius* and *Procyon*. In case of the phenomena first investigated by BESSEL, the center of gravity of the system moves uniformly on the arc of a great circle; but in this case the center of gravity moves on the arc of a very small ellipse and with a velocity which follows a very complex law. Indeed the velocity at any point of the orbit is inversely as the perpendicular from the central star to the tangent to the ellipse at the point in question; and, as the central star may in general occupy any point whatever of the apparent ellipse, we see that the velocity varies in an extremely complicated manner. In view of these facts it seems best, especially from the point of view of practical double-star work, to determine first of all the path of the center of gravity and the elements of its orbit. Suppose we designate the rectangular coordinates of this center, relative to the principle star, by x', y'; and the coordinates of the visible companion referred to the same origin by x, y; then if α and β denote the differences of these coordinates, the observations will furnish a series of equations of the form:

$$\begin{array}{ll}
\alpha_1 = x_1' - x_1 & \beta_1 = y_1' - y_1 \\
\alpha_2 = x_2' - x_2 & \beta_2 = y_2' - y_2 \\
\alpha_3 = x_3' - x_3 & \beta_3 = y_3' - y_3 \\
\alpha_4 = x_4' - x_1 & \beta_4 = y_4' - y_4 \\
\alpha_5 = x_5' - x_5 & \beta_5 = y_5' - y_5 \\
\alpha_n = x_n' - x_n & \beta_n = y_n' - y_n
\end{array}$$

Five points, each determined by two such equations, are theoretically sufficient to fix the elements of the orbit of the visible star about the common center of gravity; a larger number of equations, when combined in an advantageous manner, so as to render the errors of observation a minimum, will make the determination more exact, and define the elements with the desired precision. In case of F.70 *Ophiuchi*, SCHUR's orbit is to all appearances a good first approximation to the path of the center of gravity, but it does not seem worth while to enter upon the more refined analysis here indicated until additional measures of the visible companion have confirmed the accuracy of this hypothesis. Apart from these theoretical difficulties, the sensible perturbations of the central star upon the motion of its attendant system will give rise to obstacles which are scarcely less formidable.

(9) While we have spoken of the dark body as attending the companion, it is clear that similar phenomena would result from the action of a body revolving round the central star. In this case, however, the considerable distance which would result from a period of 36 years might render the stability of the system somewhat precarious, especially if the orbit be eccentric like that of the visible companion. And as there is every reason to suppose that the system is the outgrowth of nebular condensation, and is, therefore, adjusted to conditions of stability and permanence, it is more natural to regard the companion as the binary. In this case the small mass might give rise to a period of 36 years even if the pair be very close. The separation of the new system is not likely to be less than 0″.4, and it may be more than twice that distance. If we adopt the parallax of 0″.2 employed by SCHUR (*A.N.* 3231) it will follow that the major semi-axis of the orbit of the visible companion is 22.74 astronomical units, and the combined mass is somewhat less than 1.6 that of the sun; and hence we conclude that the orbit of the visible companion about the common

center of gravity has a major semi-axis of 1.5 astronomical units. Therefore, while the bright companion describes an eccentric orbit with a major axis, which is about a mean between those of *Uranus* and *Neptune*, the action of the dark body causes it to describe another ellipse corresponding in size to that of the planet *Mars*.

(10) With regard to the present position of the dark body we remark that an exact prediction is difficult, but the general indications are that it lies approximately in the direction of 330°. As the companion is now near periastron, the present is a favorable opportunity for searching for the dark body, since in this position the orbit will be expanded owing to the perturbations of the central star. In case it should be imagined that the unseen body attends the central star, it would be natural to locate it in the direction of 220°.

(11) Many years ago a disturbing body in the system of F.70 *Ophiuchi* was suspected by Jacob and Sir John Herschel, and on two occasions, more recently, Burnham has searched for it without success. After examining both stars with the Dearborn 18-inch refractor in 1878 he adds: "Both stars round;" while a still more critical search with the Lick 36-inch refractor led him to remark: "I could not see any third component and both stars appeared to be round, with all powers." In spite of this negative evidence, observers with great telescopes will find this system worthy of special examination. Whatever be the result of optical search for the unseen body, it will now become a matter of great interest to measure the visible companion with the most scrupulous care until the nature and extent of its perturbations are fully established.

The University of Chicago, 1895 *November* 9.

Note. The following observations, made with the Göttingen heliometer, have just been received from Professor Schur:

t	θ_o	p_o	Steadiness, definition [1 = excel.; 4 = bad]
1894.51	313.5°	2.29″	4 , 4
1894.56	304.1	2.24	3 , 3
1894.56	306.2	2.35	3 , 3
1894.78	301.6	2.17	3 , 3
1894.602	306.35	2.263	4*n* , Schur
1895.40	305.3	2.22	3 , 3
1895.41	303.2	2.40	3 , 3
1895.41	300.9	2.43	3 , 3
1895.53	303.0	2.22	3 , 3
1895.81	295.7	2.27	3 , 3
1895.512	301.62	2.308	5*n* , Schur

A NEW VARIABLE IN *SCULPTOR*,*

Arg.Gen.Catal. 404 = C.DM. $-38°$ 138. $\alpha = 0^h\ 23^m\ 2^s.8$, $\delta = -38°\ 35'\ 58''.2$, (1875.0)

By ROBERT H. WEST.

This star is given in the list of suspected variables in the introduction to the Cordoba *Durchmusterung*, Part II, where the following data are given:

	M	
1889 Nov. 25	8.5	
1890 Oct. 14	–	(not observed)
1892 Nov. 22	–	(not observed)
Dec. 15	–	(invisible)

Its variability is fully confirmed by the following observations:

	M		M
1895 Nov. 8	10.05	1895 Nov. 28	9.0
16	9.6	Dec. 2	8.8
22	9.3	7	8.6

These observations were made by Argelander's method, using the C.DM. magnitudes of the neighboring stars as standards.

1895 *December* 9.

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* This confirmation permits the definitive notation, 146 *T Sculptoris*. — Ed.

ON THE VARIATION OF THE HOLDEN-ESPIN RED STAR,

$1^h\ 46^m\ 42^s.4$, $+58°\ 32'.6$. (1855),

By J. A. PARKHURST.

Espin announced the variability of this star in *A.J.* 330. In *A.N.* 3264 he referred to Holden's observation, "1881 July 17, fine red star, 9 mag," and described its position as "the third of a line of four faint stars stretching up to sf in field with DM. 58°331, 7.5 mag., and DM. 58°334, 9.2 mag." I have measured its position referred to these two comparison-stars and DM. 58°342 with the following result:

$$\text{R.A.} = 1^h\ 48^m\ 3^s.4\,; \quad \text{Decl.} = +58°\ 38'\ 42''\ (1875)$$

The line of stars, mentioned by Espin, is about 6′ in length, and the magnitudes of the stars are as follows: $9^M.9$, $9^M.8$, V, $10^M.2$.

I have 28 comparisons of the magnitude of this star since 1894 Dec. 4. It rose very slowly from 12^M at the first observation to $10^M.5$ in July 1895, then more rapidly to a maximum, $9^M.5$, 1895 Oct. 10, then fell irregularly to 11^M at the last observation, 1895 Dec. 17. In connection with Holden's observation, quoted above, and Espin's given in *A.N.* 3264, a period of a little more than a year is suggested, if the variation is regular. The star is very red.

Marengo, Ill., 1895 *December* 19.

ELEMENTS OF COMET *d* 1895 (*BROOKS*).

BY A. JAY ROY.

The following elements of Comet *d* were derived from observations at Mt. Hamilton, Nov. 24; and at Albany, Dec. 9 and 11.

$$T = 1895 \text{ Oct. } 21.05314 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \Omega &= 83^\circ\ 5'\ 1''.6 \\ \omega &= 298\ 46\ 15.6 \\ i &= 76\ 14\ 59.7 \end{aligned}\right\} \text{Mean equinox 1895.0.}$$

$$\log q = 9.925854$$

Middle place (O – C): $D\lambda = +1''.4$, $D\beta = -1''.0$.

Printed as Supplement to No. 362.

NOTES ON TWO VARIABLE STARS.

BY W. W. CAMPBELL.

More than a year ago Dr. CHANDLER requested me to confirm the variability of the two following stars, their far-south position rendering them inconvenient for observation at most other observatories. My observations were made with the 36-inch telescope, generally through the diagonal finder of the spectroscope, when my regular work was in the region of these stars. They were discovered to be variable by the Harvard College Observatory, and my observations confirm their variability.

7151. *RU Sagittarii.*

1894 Sept. 20. The star *Argent. Gen. Catal.* 27305 ($8^{\rm M}$) is near the assigned position, and being a red star, I suspected it to be the variable. It is ¼ magnitude fainter than the $7\frac{3}{4}^{\rm M}$ star No. 27312; that is, $8^{\rm M}$.

1894 Oct. 12. The magnitude of 27305 is unchanged.

1895 Aug. 16. The suspected star is $12^{\rm M}$.

The variable is therefore *Argent. Gen. Catal.* 27305. Its position is

$$\begin{aligned} &(\text{for } 1900.0) \quad \alpha = 19^{\rm h}\ 51^{\rm m}\ 50^{\rm s}.3 \quad ; \quad \delta = -42^\circ\ 6'\ 55'' \\ &(\text{for } 1855.0) \quad \alpha = 19\ 48\ 43.7 \quad ; \quad \delta = -12\ 13\ 53 \end{aligned}$$

RT Sagittarii.[*]

1894 Sept. 20. There is a red star at some distance following the assigned position, and this I decided to observe. It is $0^{\rm M}.2$ fainter than C.DM. –39°13732, $9^{\rm M}.0$; the red star is, therefore, about $9^{\rm M}.2$.

1894 Oct. 12. The magnitude is unchanged.

1895 Aug. 16. The magnitude is unchanged.

1895 Oct. 16. The red star is about half a magnitude fainter than a star of $10^{\rm M}\pm$, which follows it by $1^{\rm s}.9$, and is 21″ further north. The variable is about 1½ magnitudes fainter than at the previous dates of observation. One or both of these stars is C.DM. –39°13722, assigned magnitude $9^{\rm M}.7$. The $10^{\rm M}$ star, which does not seem to vary in brightness, precedes C.DM. –39°13727 by $24^{\rm s}.22$, and is 1′ 44″.3 south of it. The catalogue differences are $24^{\rm s}.9$ and 1′.6. If we assume that the $10^{\rm M}\pm$ star is C.DM. –39°13722, the position of the variable becomes

$$\begin{aligned} &(\text{for } 1900.0) \quad \alpha = 20^{\rm h}\ 11^{\rm m}\ 3^{\rm s} \quad ; \quad \delta = -39^\circ\ 25'.7 \\ &(\text{for } 1855.0) \quad \alpha = 20\ 8\ 3 \quad ; \quad \delta = -39\ 33.8 \end{aligned}$$

Mt. Hamilton, Cal., 1895 *Dec.* 7.

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[*] The large error, in the original position given by the H.C. Observatory, pointed out by PAUL (XV, 133), and here confirmed by CAMPBELL, unfortunately requires a change in the number assigned to this variable in the "Revised Supplement" (XV, 84). It should be 7266, not 7255; and the places there given should be

(1900) $20^{\rm h}\ 11^{\rm m}\ 6^{\rm s}$, –39° 25′.2 ; (1855) $20^{\rm h}\ 8^{\rm m}\ 5^{\rm s}$, –39° 33′.3

NOTE ON DR. BRENDEL'S REMARKS RESPECTING γ *VIRGINIS*.

BY T. J. J. SEE.

I regret to notice that Dr. BRENDEL has given an interpretation of my remarks relative to sifting the observations of γ *Virginis*, which is entirely misleading. That remark was intended to apply to the older observers, and had no reference to living astronomers. The observations of γ *Virginis*, which I made at Berlin, were taken with extreme care, but were so nearly identical with Professor KNORRE'S results that it was quite unnecessary to add superfluous material. I have generally made use of Professor KNORRE'S measures in my work on the orbits of double stars.

The University of Chicago, 1895 *December* 4.

CORRIGENDUM.

No. 361, p. 5, col. 1, line –21 : *for* RICHARDSON *put* ROBINSON.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed January* 8.

THE

ASTRONOMICAL JOURNAL.

No. 364.

VOL. XVI. BOSTON, 1896 JANUARY 23. NO. 4

DERIVATION OF FUNDAMENTAL FORMULAS FOR THE CASSEGRAIN (AND GREGORY) TELESCOPES,

By J. M. SCHAEBERLE.

For some months past I have been experimenting in astronomical photography without the use of lenses, all the enlarged images being formed by reflection from silvered glass surfaces, forming the optical parts of a telescope.

During these preliminary experiments it became quite apparent that, with a modified form of Cassegrain telescope, as good results in planetary photography may be expected from well figured and rigidly mounted reflecting surfaces carried by a tube not more than twelve or fifteen feet long, as have been obtained with the most powerful photographic refractors of larger aperture in use at the present time.

There seems to be but very little published on the theory of the Cassegrain and Gregory telescopes; in fact, all that I can find on this subject is the general statement that the curvature of the secondary mirror for the first mentioned form should be hyperbolic, and elliptical for the other case.

A formula for the magnifying power of such telescopes is given in the *Encyclopedia Britannica*, but the formula is certainly wrong. HOUZEAU in his exhaustive work gives no references to any published papers, and indeed does not even mention Cassegrain's name, so far as I can learn. Under these circumstances, and in view of the encouraging results so far obtained, this paper has been prepared in the belief that the matter here presented will be of value to astronomers. For a description of the reflecting telescope (actually mounted at the Lick Observatory), and of some photographs taken with it, those interested are referred to the *Publications of the Astronomical Society of the Pacific*, Nos. 42 and 44, and to the October 1895 number of the *Photographic Times*.

The ordinary form of Cassegrain and Gregory telescopes is that in which the image examined is in or near the plane of the large reflector. For photographic purposes the principal objection to this plan is that the sensitive plate is there exposed to too large a sky-area. To diminish this area the plate should be carried at the lower end of a tube whose axis coincides with the produced axis of the main tube. In this way the diffused light from the sky-area (to which the plate is exposed) can be made even less than that emitted from the objective of a refractor.

For photographing the sun or the moon the secondary mirror must be backed by a concentric circular disk of such a diameter that all *direct* light is cut off from the sensitive plate. As there is no dense matter (glass) to reflect and diffuse light the field of view is actually darker than it is for a refracting telescope; for only a very small percentage of the diffused light from the large mirror is reflected to the photographic plate by the secondary.

As is well known, the only form of continuous surface which will by reflection converge parallel rays to a point, is that of a paraboloid of revolution; the point or focus being in the axis of revolution.

If such converging rays are again reflected from a second continuous surface, in such a way that all the rays are made to pass through a second point on the optical axis, it has been proved that the form of this surface must be either the convex side of an hyperboloid, or the concave side of an ellipsoid of revolution. In the former case the rays are reflected before reaching the primary focus, while in the latter case the reflection takes place after rays have passed through the focus. In both cases the axis and nearer focus of the secondary reflecting surface must exactly coincide with the axis and focus of the parabolic surface.

A well known property of the hyperbola and ellipse is that lines drawn from the two foci (of either curve) to any point of the curve make equal angles with a tangent, and consequently with a normal, to the curve at that point.

To avoid unnecessary repetition of formulas, I shall first deduce the equations for the Cassegrain form of telescope in which the secondary reflection takes place at the convex side of the hyperboloid, and then show that identically the same formulas apply to the Gregory telescope.

As the focus and axis of the hyperboloid must coincide with the focus and axis of the paraboloid, all originally parallel rays are, after reflection from the first-named surface, directed to the focus of the hyperboloid surface; that portion of any ray (line) intercepted between this surface and the focus is one radius-vector of the hyperbola, and the portion of the reflected ray included between the point of reflection and the intersection (secondary focus) of this reflected ray with the axis, is the other radius-vector of the same hyperbola.

Consequently all exterior radial lines converging to one focus of an hyperboloid of revolution will, after reflection from the convex surface of this hyperboloid, converge to another point on the axis. This last mentioned point is where the focal image of the Cassegrain telescope is formed.

Now let F denote the focal length of the parabolic reflector, and let the distance between a plane tangent to the center of this reflector and the photographic plate (or secondary focus) be called H; the sign of H being positive so long as the distance of the plate from the principal focus is greater than F, and negative when the plate is between the two reflectors.

Let r, e and A denote respectively, the axial radius of curvature, the eccentricty, and the major semi-axis of the hyperboloid of revolution forming the convex secondary reflecting surface.

In actual practice the observed angular dimensions will always be small, so that we can, without sensible error, call the distance from each focus to any point of the reflecting surface actually used, the same as the focal distance, or $A(e-1)$ and $A(e+1)$.

If α' denotes the angle which a ray (originally directed towards the focus) makes with the optical axis after reflection from the hyperbolic mirror, and θ the angle which a normal at the point of incidence makes with the axis, then the angle which the incident ray makes with the axis will always be $2\theta+\alpha'$, or, if the quadrant were taken into consideration, $180^\circ-(2\theta+\alpha')$.

If p denotes the perpendicular distance of the point of incidence from the axis we have, without sensible error,

$$(1) \qquad p = A(e+1)\tan\alpha' = r\tan\theta$$

Substituting for e its value

$$(2) \qquad r = A(e^2-1)$$

we obtain the relation

$$(3) \qquad \tan\theta = \frac{\tan\alpha'}{e-1}$$

To obtain an expression for the equivalent focal length, L, of the combination in terms of F, H and r, let 2δ denote the linear diameter of an image in the principal focal plane which subtends the angle 2α at the distance F, and let $2\alpha'$ be the angle which the same image subtends at the distance $F+H$. The relation between α and α' is then given by the equation

$$(4) \qquad \delta = (F+H)\tan\alpha' = F\tan\alpha$$

$$(5) \qquad \text{or} \qquad \tan\alpha = \frac{F+H}{F}\tan\alpha'$$

Now if the angular diameter of the primary image as seen at the distance F is 2α, the angular diameter of the enlarged image seen at the distance $F+H$ is evidently $2(2\theta+\alpha')$. The *linear* diameter of the enlarged image divided by the *linear* diameter of the primary image is evidently equal to the ratio $\frac{L}{F}$, or

$$\frac{(F+H)\tan(2\theta+\alpha')}{F\tan\alpha} = \frac{L}{F} \qquad (6)$$

Since θ and α' are always very small we can write, without sensible error,

$$\tan(2\theta+\alpha') = 2\tan\theta+\tan\alpha' \qquad (7)$$

Substituting for $\tan\theta$ in equation (6) its value given by equation (3), and for $\tan\alpha$ its value given by equation (5), we obtain

$$L = F\,.\,\frac{e+1}{e-1} \qquad (8)$$

The expression for the eccentricity of the secondary in terms of F and L is therefore

$$e = \frac{L+F}{L-F} \qquad (9)$$

As the distance $F+H$ is the same as the distance between the two foci, we have

$$F+H = 2Ae \qquad (10)$$

Eliminating A from equations (2) and (10), we obtain an expression for the eccentricity in terms of $F+H$ and r, or

$$e = \frac{r\pm\sqrt{(F+H)^2+r^2}}{F+H} \qquad (11)$$

Equating the second members of (2) and (11) we obtain, finally, the fundamental equations

$$L = \frac{F}{r}\left((F+H)\pm\sqrt{r^2+(F+H)^2}\right) \qquad (12)$$

$$r = \frac{2LF(F+H)}{L^2-F^2} \qquad (13)$$

$$H = \frac{r(L^2-F^2)}{2LF}-F \qquad (14)$$

To show that these equations also hold good for the Gregory form of telescope, we have but to remember that, for the ellipse, e is less than unity; we therefore substitute for e^2-1 and $e-1$ the values $1-e^2$ and $1-e$ in equations (2) and (3); and also write $2\theta-\alpha'$ in place of $2\theta+\alpha'$ in equation (6), as the former expression will now be the measure of the angle which the incident ray makes with the axis. The expressions resulting from these substitutions will be found to be identical with equations (12), (13) and (14).

When $e = 0$, equation (11) shows that r must be infinite, consequently L must equal F according to equation (13); for these values H becomes indeterminate according to equation (14). The reflecting surface for this case is therefore a plane; the equivalent focal length is the same as that of the parabolic mirror, so that the size of the image is the same for all values of H giving possible results. The plane mirror is used in the Newtonian form of telescope; H is negative, and as a rule made numerically equal to $F-\frac{1}{2}D$, in which D is the diameter of the parabolic reflector. But the secondary focus, instead of being on the main optical axis, is made to lie on a line at right angles to this axis by tilting the mirror (which is placed at the distance $\frac{1}{2}D$ from the focus) through an angle of 45°. There is evidently no distortion of the image for any possible inclination of a *plane* mirror.

For the critical case when $e = 1$, it appears from equation (9) that whether the reflection is conceived to take place from the convex (Cassegrain), or from the concave (Gregory) side of the paraboloid, L must always be infinite for all finite values of r, so that according to equation (14) H must also be infinite; the value of r is, therefore, according to equation (13), indeterminate. A secondary convex (or concave) parabolic reflector, therefore, again renders parallel the originally parallel rays impinging upon the large mirror, whatever the radius of curvature (r) of the secondary parabolic mirror may be.

The uses of the fundamental equations (12), (13) and (14), are as follows:

1st. If both mirrors are already finished, and their constants measured, the equivalent focal length L, for any value of H, can at once be found by means of equation (12); the adopted value of H should always be that for which the definition is best, viz.: that used while figuring the small mirror.

2d. If the large mirror is finished, and it is desired to have a given equivalent focal length L for any convenient value of H, equation (13) will give the radius of curvature to which the secondary must be ground. All the testing during the process of figuring should thus be made at the distance H from the large mirror.

3d. If both mirrors are finished, and it is desired to have (within certain limits on each side of H) a particular scale for the image, equation (14) will, for a given value of L, give the distance H, from the large mirror, at which the photographic plate must be placed to produce the desired scale.

All the foregoing formulas refer to the theoretical condition of perfect definition of an infinitely distant point on the optical axis. In practice the angular area of the secondary reflector actually doing service is so small that the sphere, the ellipsoid of any eccentricity, the paraboloid and the hyperboloid of any eccentricity will, for the same value of r, be so nearly coincident with the surface of the secondary mirror of radius r that all of these surfaces will give moderately well defined images, which can be made to vary in size simply by shifting the secondary along the optical axis of the telescope, thereby causing corresponding changes in L and H.

Each change of position really assumes a change in the eccentricity of the secondary, but since this element is fixed in a given mirror there is only one value of H (and L) for a given secondary, and that value fixes the point at which perfect definition is secured. If the secondary mirror is ground to the surface of a paraboloid of revolution there is no such point to be found. For each of the two forms of telescopes here considered there will always be a particular point on the optical axis at which the definition is best for a particular secondary; but as the resulting value of H for this point (found by trial) may be inconveniently large or detrimentally small, the eccentricity of the secondary must be changed by local polishing until a suitable position for the photographic plate is obtained. This can only be accomplished by repeated trials in the telescope, as no system of direct measurement is sufficiently delicate to guide the optician.

In my own experiments (with the Cassegrain form), to save the labor of the rough grinding, a number of lenses, whose surface radii of curvature ranged between 6 inches and 72 inches, were first secured.

All of these surfaces gave by reflection very imperfect images when used in connection with my 18-inch parabolic mirror. After patient polishing (mostly by strokes of the reflector across the diameters of a zonal polisher) and repeated testing in the telescope, a fairly good surface, giving a focal length of about 80 feet, was obtained. Later a practically perfect figure was given to another surface having a radius of curvature of about 14 inches (14.25 inches by measurement), for $H = 10$ inches.

The photographic plateholder is supported at the lower end of a sliding tube, giving a range from $H = 3$ feet to $H = 4$ feet. Between these limits the definition appears to be about equally good, although the figuring of the secondary was carried on for $H = 10$ inches; this distance was afterwards increased (in order to reduce the sky-area) without any apparent loss of definition.

As the focal length of the 18-inch mirror is 12.384 feet, and the radius of curvature of the hyperbolic mirror 1.188 feet, the range of L is according to equation (12)

For $H = 3$ feet . . . . $L = 321.2$ feet
$H = 4$ feet . . . . $L = 342.0$ feet

From this it appears that L here increases about 20 times as fast as H. The differential coefficient of L with respect to H, regarding F and r as constants, is according to equation (14)

$$\frac{dL}{dH} = \frac{2LF^2}{r(L^2+F^2)} \qquad (15)$$

which will give the rate for any values of F, r and H.

For photographing the moon and all the major planets except *Venus* and *Mercury* it is necessary to give times of exposure, varying all the way from a small fractional part of a minute up to several minutes; it is therefore necessary to have a guiding eyepiece in addition to the driving clock. The one I use is fastened to the plate holder and has a focal length of about two inches, giving, therefore, magnifying powers of 1927 and 2052 for $H = 3$ and $H = 4$ feet respectively. While the guiding objects are ordinarily much over magnified, still, for the purposes of following, these high powers are of great advantage.

If a telescope is so mounted that the parabolic mirror is about midway between the photographic plate and the secondary mirror, (or when H is about equal to F) a plate having practically four times the area of the aperture in the large mirror can be completely covered with all the rays which pass through this aperture (coming from any celestial objects, as the sun, moon or a cluster of stars) that are reflected from the small mirror, provided the radius of curvature (r) of the latter is small, or, in other words, when equivalent focal length L is large. In general the size of the plate which receives all the light available increases with H.

The disturbing effect of the wind (on the instrument mounted in the open air at the Lick Observatory) is the greatest source of trouble yet to be overcome.

Lick Observatory, 1895 *November* 29.

ON STANDARD SYSTEMS OF DECLINATION AND PROPER MOTION,

By S. C. CHANDLER.

It is here proposed to present the conclusions, alluded to at the end of the article in no. 361, to which a study of the declinations and proper motions there given seems naturally to lead us. Table I following gives, in columns 2 and 3, the mean epochs and seconds of the declinations derived, by weights, from the two series on p. 3, l. c. These values will be hereafter denoted by C; while those of Boss will be called B, and those of Auwers's *Fundmental-Catalog* will be called A; and the several systems of proper motion will be correspondingly symbolized.

With regard to the declinations C, it is to be remarked that they are free from latitude-variation; that the sine-flexure is eliminated, while the correction for cosine-flexure, if any exist, is theoretically zero at $\delta = +13°$, and practically so for all our stars south of $+25°$, at least; that the effect of accidental division-errors has been practically eliminated, and that of periodical division-errors must be small. Further, our declinations and proper motions are absolutely independent of Auwers, and practically so of Boss.*

It therefore seems legitimate to use our results C as a satisfactory test of the correctness of the systems A and B.

In the column $C-B'$ the symbol B' denotes Boss's declinations corrected for variation of latitude, in the following manner. In any catalogue covering a series of years the effect of the 428-day term is eliminated, while that of the annual terms remains. Assuming the average mean time of the observations to be $10^h\ 30^m$, the average right-ascension of stars observed on any given date will be $\alpha = \odot + 158°$. By eq. (52), *A.J.* XIV, 75, the annual term for 1832.5 is, for the Greenwich meridian, $-0''.155 \cos(\odot - 359°)$. Hence the correction of the declinations is $+0''.155 \sin(\alpha + 113°)$. But, of the catalogues before 1850 on which Boss's normal system rests, thirteen (wt. 25) were deduced by the use of nadir or horizontal points, and five (wt. 18) by polar points. The former are affected by latitude-variation, the latter not. Hence we reduce the above coefficient and take $+0''.11 \sin(\alpha + 113°)$ as the correction to Boss's declinations for the epoch in question. The column $C-B'$, then, is free from latitude-variation. That we have ascertained the correction satisfactorily is shown by the fact that the manifest systematic character of the signs in column $C-B$ now disappears. Indeed, if we derive empirically a periodical expression for the column $C-B$ we get $+0''.112 \sin(\alpha + 111°)$, which is almost identical with the above.

The smallness of the differences $C-B'$ is quite surprising. The average value is $+0''.02$; or, without regard to sign, $\pm 0''.08$. An inspection of this column in tables I and II — which tables contain the same data, under corresponding headings, arranged in order of right-ascension and declination, respectively — shows in $C-B'$ no systematic character. The column $C-A$, on the contrary, shows large differences, depending on the declination. It cannot be otherwise construed than as the measure principally, for this epoch, of the errors of Bradley's quadrant.

Coming to the proper motions, we find in $C-A$ a large systematic difference, also depending on declination: but in $C-B$ not even a trace of such a relation. The average differences are $-0''.0070$ and $+0''.0020$ — or, taken without regard to sign, $\pm 0''.0125$ and $\pm 0''.0035$ — for $C-A$ and $C-B$, respectively. The discordances are thus nearly four times as great for the proper motions of the *Fundamental-Catalog* as for Boss. Allowing for the constant difference $C-B = +0''.002$, we find the probable error of a single difference $C-B$, $\pm 0''.0029$. The average value of the probable error of Boss's proper motions, for these stars, is $\pm 0''.0023$, whence the probable accidental error of our proper motions is $\pm 0''.0018$.

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* In the formation of Boss's fundamental system, the Greenwich 12-year Catalogue enters with a weight of only 4 in a total of 73; and, besides, the proportion of the observations of that catalogue, used in forming C, is small. Indeed, our declinations could be made absolutely independent of Boss by using only the Pond series (1825-35); and the inferences hereinafter drawn would in no wise be affected.

TABLE I. ORDER OF RIGHT-ASCENSION.

*	Epoch	δ 1830	$\Delta\delta$ C−A	$\Delta\delta$ C−B	$\Delta\delta$ C−B′	$\Delta\mu'$ C−A	$\Delta\mu'$ C−B
		″	″	″	″	″	″
1	32.0	5.89	+0.60	+0.11	+0.01	−0.009	+0.002
2	32.0	17.24	+0.36	− .01	− .11	− .006	.000
3	36.2	13.36	+0.14	+ .06	− .03	− .002	+ .001
4	33.5	8.53	–	+ .06	− .03	–	–
5	31.2	16.11	+0.82	− .04	− .11	− .018	− .001
6	32.3	35.86	+0.66	+ .05	+ .05	− .011	− .003
7	35.7	53.75	+0.76	+ .11	+ .12	− .006	+ .004
8	32.3	18.34	+0.22	+ .17	+ .19	+ .002	+ .003
9	31.6	3.58	+0.79	− .02	+ .01	− .020	− .003
10	31.4	9.19	+0.55	− .01	+ .06	+ .006	+ .006
12	32.2	44.88	+0.20	− .09	− .02	− .010	− .004
13	32.8	40.90	+1.01	− .04	+ .06	− .017	+ .002
15	35.8	0.21	−0.41	− .11	.00	.000	− .005
16	32.6	13.53	+0.92	− .29	− .18	− .024	+ .003
17	34.4	39.73	−0.30	− .11	− .01	+ .010*	+ .003
18	32.6	25.71	−0.15	− .18	− .11	+ .002	+ .012
19	33.4	15.85	+0.92	− .07	.00	− .020	+ .003
20	32.2	42.43	–	+ .02	+ .07	–	+ .008
21	34.9	1.09	−0.28	+ .23	+ .28	+ .008*	− .001
22	31.6	30.19	+0.15	− .13	− .10	− .006	.000
23	29.7	58.53	+1.03	− .11	− .08	− .015	+ .007
24	30.4	25.91	+0.63	+ .02	+ .01	− .003	+ .001
25	32.3	25.51	+1.30	+ .14	+ .12	− .017	+ .003
26	35.0	48.68	+0.95	+ .15	+ .10	− .020	+ .003
27	31.5	13.27	+1.22	− .05	− .10	− .024	+ .010
28	31.7	1.35	+1.06	+ .06	.00	− .016	− .002
29	32.3	45.56	−0.14	+ .12	+ .05	+ .003	− .004
30	33.2	17 94	+0.97	− .01	− .09	− .019	− .003
31	30.3	32.16	+1.03	+ .20	+ .12	− .014	.000
32	33.3	17.76	+1.01	+ .18	+ .10	− .016	+ .003
33	31.8	35.24	+0.61	+ .11	+ .02	− .010*	+ .001
34	35.6	2.66	−0.38	+ .22	+ .12	+ .026	+ .009
35	33.8	56.09	−0.29	+ .21	+ .10	+ .014	+ .007
36	31.8	32.22	+1.01	+0.04	−0.07	−0.018	+0.002

TABLE II. ORDER OF DECLINATION.

*	δ	$\Delta\delta$ C−A	$\Delta\delta$ C−B′	$\Delta\mu'$ C−A	$\Delta\mu'$ C−B	Correction 1895 A
	°	″	″	″	″	″
32	6.0	+1.01	+0.10	−0.016	+0.003	−0.48
23	7.0	+1.03	− .08	− .015	+ .007	− .55
9	7.4	+0.79	+ .01	− .020	− .003	− .62
31	8.4	+1.03	+ .12	− .014	.000	− .36
30	10.2	+0.97	− .09	− .019	− .003	− .46
25	12.7	+1.30	+ .12	− .017	+ .003	− .51
13	12.8	+1.01	+ .06	− .017	+ .002	− .63
28	13.6	+1.06	.00	− .016	− .002	− .39
2	14.2	+0.36	− .11	− .006	.000	− .17
36	14.3	+1.01	− .07	− .018	+ .002	− .52
24	14.6	+0.63	+ .01	− .003	+ .001	− .03
6	16.2	+0.66	+ .05	− .011	− .003	− .31
19	20.1	+0.92	.00	− .020	+ .003	− .68
16	21.5	+0.92	− .18	− .024	+ .003	− .83
5	22.7	+0.82	− .11	− .018	− .001	− .54
22	27.3	+0.15	− .10	− .006	.000	− .16
20	27.8	–	+ .07	–	+ .008	–
1	28.2	+0.60	+ .01	− .009	+ .002	− .29
12	28.4	+0 20	− .02	− .010	− .004	− .35
8	28.5	+0.22	+ .19	+ .002	+ .003	− .07
10	32.3	+0.55	+ .06	+ .006	+ .006	.00
27	33.2	+1.22	− .10	− .024	+ .010	− .79
26	38.6	+0.95	+ .10	− .020	+ .003	− .61
33	44.7	+0.61	+ .02	− .010	+ .001	− .26
7	45.8	+0.76	+ .12	− .006	+ .004	− .31
3	55.6	+0.14	− .03	− .002	+ .001	− .06
17	58.0	−0.30	− .01	+ .010	+ .003	+ .22
34	61.9	−0.38	+ .12	+ .026	+ .009	+ .74
15	62.7	−0.41	.00	.000	− .005	+ .01
18	65.2	−0.15	− .11	+ .002	+ .012	− .10
29	67.4	−0.14	+ .05	+ .003	− .004	+ .23
35	69.8	−0.29	+ .10	+ .014	+ .007	+ .41
21	74.8	−0.28	+ .28	+0.008	−0.001	+0.28
4	88.4	–	−0.03	–	–	–

* The proper motions are used as given in AUWERS's *Fundamental-Catalog, i.e.*, +0″.002 for no. 17 (*δ Ursae Majoris*); −0″.005 for no.21 (*β Ursae minoris*); and +0″.003 for no. 33 (*α Cygni*). But the data given in his reduction of BRADLEY, would give +0″.004, +0″.005 and −0″.003 for these stars, respectively. These errors have been perpetuated in the Berlin *Jahrbuch* up to the present time.

The real meaning of these comparisons can hardly be mistaken. Taking them together with other facts pointing in the same direction we must conclude that the system of the *Fundamental-Catalog*, admirable as it was for its original purpose, has now broken down, and that the extension of its employment up to the present time, and certainly for the future, should cease. The use of BRADLEY as absolute, for computing proper motions, was shown by the inexorable logic of BOSS, twenty years ago, to be a principle that must be abandoned. The result proves the soundness of his conclusions. How serious the errors of the *Fundamental-Catalog* system at the present time probably are, may be seen by the last column of Table II, which contains its corrections for these stars in 1895, using the means between the proper motions *B* and *C*, and including the corrections for variations of latitude, assuming the latter to be the same now as for the epoch 1865, found in *A.J.* XIII, 63.

While objection may be made on minor points of numerical detail in the present discussion, I think the main conclusion must stand. What BOSS demonstrated a quarter of a century ago ought now to be plain to all, that to continue the prevalent practice of elaborately deducing declinations and proper motions, from catalogues of various epochs, by the use of systematic corrections referred to a fundamental system resting absolutely on BRADLEY, is simply to spoil good observations made with our refined modern instruments, and to perpetuate, in continually increasing ratio, the defects of BIRD's old mural quadrant.

Cambridge, 1895 *December* 28.

LIST OF ADDITIONAL ERRORS FOUND IN THE CORDOBA CATALOGUES,

BY JOHN M. THOME.

I send a list of errata, which may be useful. With the exception of a few cases, which I am still trying to unravel, this list will, I think, be found exhaustive for the Cordoba Catalogues as far south as the parallel of 52°.

Zone Catalogue. — Vol. VII.

Page	Star	Column	For	Put	
62	925	Decl. Austr.	53′	23′	
118	2131, 2133	. . .	. . .	. . .	same star
247	4583	Asc. Recta.	$31^s.62$	$28^s.36$	same as 4573
264	1080, 1083	. . .	. . .	. . .	same star
295	3854, 3858	. . .	. . .	. . .	same star
297	4049	Mag.	9½	7½	
308	294	Asc. Recta.	$3^s.12$	$2^s.06$	same as 291
312	635, 637	. . .	. . .	. . .	same star
331	2401, 2407	. . .	. . .	. . .	same star
341	3341	Asc. Recta,	$49^s.32$	$39^s.32$	same as 3328
384	2870	Decl. Austr.	32′	36′	

Zone Catalogue. — Vol. VIII.

Page	Star	Column	For	Put	
12	1059	Mag.	7	9	
14	460	Decl. Austr.	27″.3	37″.3	
51	1095	Asc. Recta,	$18^m 13^s.47$	$17^m 55^s.72$	same as 1083
		Decl. Austr.	50″.2	50″.0	
65	2520	Asc. Recta.	$42^s.66$	$32^s.66$	
125	631	Asc. Recta,	$11^s.38$	$8^s.52$	
168	373	Asc. Recta.	$4^m 59^s.15$	$5^m 1^s.71$	same as 380
202	3643	Asc. Recta,	$51^s.49$	$61^s.49$	
251	218	Asc. Recta,	$11^s.86$	$1^s.86$	same as 207
259	696	Asc. Recta.	$25^s.49$	$42^s.67$	
		Decl. Austr.	7″.7	7″.8	
272	2088	Asc. Recta.	$13^s.26$	$19^s.79$	same as 2095
289	765	Mag.	9½	7½	
366	242	Asc. Recta,	$8^m 55^s.39$	$9^m 13^s.95$	

General Catalogue. — Vol. XIV.

Page	Star	Column	For	Put	
202	10294	Asc. Recta	$11^s.31$	$12^s.31$	
219	11145	Decl. Austr.	24′	25′	
243	12388	Decl. Austr.	11″.3	13″.6	
253	12899	Decl. Austr.	32″.3	26″.3	
306	15498	Asc. Recta	$27^s.97$	$26^s.97$	
334	17028	Decl. Austr.	7″.8	5″.3	
358	18430	Decl. Austr.	37″.8	27″.8	
365	18791	Decl. Austr.	48′ 41″.7	49′ 14″.8	
416	21660	Decl. Austr.	15″.0	10″.0	
438	22805	Decl. Austr.	15″.8	5″.8	
452	23581	Decl. Austr.	32″.6	42″.6	
489	25620	Asc. Recta,	$4^s.54$	$14^s.54$	same as 25626
		Decl. Austr.	39″.0	49″.0	
564	29811	Asc. Recta,	$53^s.91$	$54^s.52$	

Stars not Found in Two DM. Zones.

Vol. VII.			Vol. VIII.		
Page	Star	Column	Page	Star	
132	1114	prob. 27′	141	2202	
138	1759	same as 1772?	162	4094	
157	372	. . .	. . .	. . .	probably 43°
169	1511	. . .	. . .	. . .	
213	4211	prob. 54′	. . .	. . .	
363	950	prob. 3′	. . .	. . .	

Vol. XIV.

284	14464	prob. 29′	. . .	. . .

Cordoba DM. — Vol. XVI.

Page	Star	Column	For	Put
37	10973½	. . .	. . .	$17^m 2^s.0$, $-22° 27′.7$
117	–	Number	19000-038	18100–18138
180	688	Mag.	6.0	9.0
184	1766	Ref.	ZC	OA
220	12601	. . .	. . .	does not exist
228	15231	Decl.	38′.8	8′.8
232	16292	Mag.	9.2	9.9
260	7706	Mag.	8.8	9.8
282	14432	Ref.	ZC	–
313	6667	. . .	. . .	does not exist — see 26°
317	8011	Decl.	51′.1	56′.1
339	14583	Mag.	9.1	9.8
343	15671	Decl.	45′.8	17′.0
373	7946	. . .	. . .	dpl
405	17523	Decl.	32′.0	22′.0
517	13504	A.R.	$53^s.9$	$13^s.9$

Cordoba, 1895 *October* 7.

THE RE-APPEARANCE OF COMET 1889 V,

BY CHARLES LANE POOR.

The mean elements for the coming approach of this comet were published in the *Astronomical Journal*, no. 320, and are as follows:

Epoch 1896 Oct. 23.5 Greenwich M.T.

$$\left.\begin{array}{rcrrr} & & ° & ′ & ″ \\ \pi & = & 1 & 48 & 12.42 \\ \Omega & = & 18 & 1 & 7.70 \\ i & = & 6 & 3 & 33.66 \\ \omega & = & 343 & 47 & 34.72 \end{array}\right\} 1896.0$$

$$\begin{array}{rcl} \log a & = & 0.5673406 \\ \log e & = & 9.6715748 \\ \log \mu & = & 2.6989957 \\ T & = & 1896 \text{ Nov. } 3.9382 \text{ Greenw. M.T.} \end{array}$$

With these I have had computed a complete ephemeris for the year 1896, of which I append a portion in the form of a finding ephemeris.

It will be seen that in the early part of February the theoretical brightness of the comet is 0.09; that at the time of discovery in 1889 being taken as unity. That is, during next month, the comet will be brighter than when last seen at the Lick Observatory in 1891. However, it will be very unfavorably situated for observations, having a large south declination. It may be possible to find it with a large glass, or perhaps to photograph it with a doublet and a long exposure. During the following months, however, the comet increases rapidly in brightness, and should be found by March or April at the latest. I hope that a careful search for it will be made, and that when it is discovered extended series of observations will be undertaken and carried out during the whole period of visibility.

In my investigations of this remarkable comet, I found impossible a complete solution of the various problems, and expressed all my results in terms of an indeterminate, r. In the subjoined ephemeris I give, for a few dates, the variations of the apparent right-ascension and declination for the probable maximum positive and negative values of r.

Finding Ephemeris for Comet 1889 V.

Gr. M.T. 1896	Apparent α $r=0$	Δα	Apparent δ $r=0$	Δδ	log Δ	Br.
	h m s	m s	° ′ ″	′ ″		
Jan. 29.5	18 47 17.2	±1 40	−27 32 28	±1 45	0.56996	0.08
Feb. 2.5	54 31.7		26 45			
6.5	19 1 46.4		19 59			
10.5	9 1.2		12 10			
14.5	16 15.5		3 19		0.54638	
Feb. 18.5	19 23 28.8		−26 53 28			
22.5	30 41.0		42 38			
26.5	37 51.6		30 53			
Mar. 1.5	45 0.6	±1 56	18 11	±5 20	0.51821	0.11
5.5	52 7.5		4 36			
9.5	59 12.0		−25 50 10			
13.5	20 6 14.7		34 57			
17.5	13 12.2		18 59		0.48546	
21.5	20 7 2		2 22			
25.5	26 58.4		−24 45 5			
29.5	33 45.5		27 15			
Apr. 2.5	40 28.2	±2 24	8 54	±9 40	0.44809	0.20
6.5	47 6.3		−23 50 4			
10.5	53 39.2		30 53			
14.5	21 0 6.3		11 26			
18.5	6 27.5		−22 51 47		0.40613	
22.5	12 42.2		32 0			
26.5	18 50.0		12 12			
30.5	24 50.6		−21 52 28			
May 4.5	30 43.6	±2 56	32 48	±14 6	0.35966	0.29

FILAR-MICROMETER OBSERVATIONS OF FAYE'S COMET,

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

By ORMOND STONE.

1895 Charlottesville M.T.	∗	No. Comp.	☄ − ∗ Δα	☄ − ∗ Δδ	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 12 8 33 8	8	4 , 4	+0 3.18	−0 44.2	21 33 23.57	−5 53 0.0	9.446	0.773
13 7 13 8	9	4 , 4	+0 3.24	−2 26.3	21 34 32.13	−5 54 7.2	9.143	0.781
15 7 27 8	11	4 , 4	+0 6.05	+1 37.5	21 37 2.76	−5 55 50.8	9.247	0.780
16 7 40 1	12	4 , 4	−0 2.80	+0 4.7	21 38 21.21	−5 56 29.9	9.373	0.777
18 7 7 35	13	20 , 4*	+1 2.12	+1 2.0	21 40 56.19	−5 57 7.0	9.190	0.775

Mean Places for 1895.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
8	21 33 17.31	+3.08	−5 52 29.3	+13.5	Comparison with ∗9
9	21 34 25.82	+3.07	−5 51 54.7	+13.8	Rumker, Nachtrag 92
10	21 39 1.83	+3.07	−5 58 58.2	+14.1	½ (first + second) Munich Catalogues
11	21 36 53.65	+3.06	−5 57 41.9	+13.6	Comparison with ∗10
12	21 38 20.96	+3.05	−5 56 48.3	+13.7	Comparison with ∗10
13	21 39 51.02	+3.05	−5 58 22.8	+13.8	½ (first + second) Munich Catalogues

* On Nov. 18 the differences of right-ascension and declination were observed; on the remaining nights, position-angles and distances. The comet was always very faint and small.

OBSERVATIONS OF LONG-PERIOD VARIABLES,

By PAUL S. YENDELL.

906. *R Trianguli.*

From 1895 August 26 to 1896 January 11, I have thirty observations of this variable. It was first seen on the former date, and its magnitude estimated as 10M.7. It increased rapidly and steadily to a maximum of 6M.5, which is indicated on November 12; there are some indications of a double maximum, but a generalized curve gives the above date. At the last observation, it had decreased to 8M.0.

1623. *T Camelopardalis.*

I began observing this star, 1895 November 27, on which date I estimated its light at 8M.9. It increased to 8M.6, which it reached on December 4, after which it fell off sharply to 9M.0, at which brightness it was observed on

December 16. From this time it again increased rapidly, passing a maximum of $8^{M}.2$ on December 25, since which it has steadily declined, its brightness at the last observation, 1896 January 11, being $9^{M}.2$.

The star was observed twelve times.

7795. *RV Cygni.*

I have twenty observations of *RV Cygni*, rather unevenly spaced, between 1895 April 23 and 1896 January 11. At the first date I found the star $8^{M}.8$; four observations to June 19 show a decrease to $9^{M}.5$; a gap occurs in the observations from this date to August 18, when the star was again observed at $9^{M}.5$; it began to increase rather rapidly in September, and in November had reached $7^{M}.75$, from which it again decreased rapidly, having fallen to $8^{M}.5$ at the last observation. A generalized curve indicates a minimum of $9^{M}.5$ on July 8, and a maximum of $7^{M}.75$ on November 15.

8324. *V Cassiopeae.*

I have thirty observations of this star, from 1895 July 28 to December 3. It was estimated at $9^{M}.9$ at the first observation, and rose rather irregularly to a maximum of $7^{M}.5$, which is indicated on October 20. At the last observation it had fallen to $8^{M}.8$.

8594. *V Cephei.*

I have fifteen observations of this star during the year 1895. These indicate a minimum of $6^{M}.9$ on 1895 July 8.

Dorchester, Mass., 1896 *January* 13.

ON THE VARIABILITY OF DM. 17°4367,

By PAUL S. YENDELL.

Since the announcement in the *Boston Transcript* of the variability of this star, I have observed it on every date when it has been possible to do so.

On 1895 December 31, the star was found six steps below its normal brightness, and its light was estimated at $9^{M}.5$. On 1896 January 5, it was invisible in my telescope at $5^{h}\,40^{m}$, $6^{h}\,5^{m}$, and $6^{h}\,20^{m}$, Local Mean Time, the limit of vision being estimated at the time as about the eleventh magnitude.

These observations confirm the fact of the star's variability, and probably its type; in my opinion, however, sufficient data have not yet been secured for the certain determination of its period.

Dorchester, Mass., 1896 *January* 11.

EPHEMERIS OF COMET *c* 1895 (*PERRINE*),

By C. D. PERRINE.

The following ephemeris has been constructed from Professor CAMPBELL's elements, published in *A.J.*, no. 361.

CONSTANTS FOR THE EQUATOR 1896.0.

$$x = r[9.96317]\sin(35^{\circ}\,31'.34+v)$$
$$y = r[9.99649]\sin(128\;\;40.19+v)$$
$$z = r[9.61788]\sin(234\;\;56.44+v)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1896	App. α	App. δ	log r	log Δ	Br.
	h m	° ′			
Jan. 21.5	19 36.2	−9 20	0.001	0.285	0.65
25.5	38.1	−8 1	0.036		
29.5	19 39.8	−6 47	0.069	0.311	0.42
Feb. 2.5	19 41.4	−5 35	0.098		
6.5	42.8	−4 26	0.124	0.331	0.29
10.5	44.0	−3 19	0.149		
14.5	45.1	−2 13	0.171	0.343	0.22
16.5	45.6	−1 39			
18.5	45.9	−1 7	0.192		
20.5	46.3	−0 33			
22.5	46.6	−0 2	0.212	0.352	0.18
24.5	46.7	+0 31			
26.5	46.9	+1 4	0.231		
28.5	47.0	+1 37			
Mar. 1.5	19 47.0	+2 9	0.248	0.358	0.14

Lick Observatory, 1896 *January* 5.

NEW ASTEROIDS.

Prof. KREUTZ has communicated the discovery of two small planets by CHARLOIS January 7.

CH $12\frac{1}{2}^{M}$ Jan. 8. $8^{h}\,15^{m}.5$ Nice M.T. $\alpha = 7^{h}\;4^{m}\,58^{s}.6$. $\delta = +24^{\circ}\,54'\,16''$. Daily motion, -60^{s} in α, and $4'$ northward.

CJ $13\frac{1}{2}^{M}$ " $9^{h}\,15^{m}.8$ " " $\alpha = 7^{h}\,20^{m}\,54^{s}.3$. $\delta = +22^{\circ}\,21'\,38''$. Daily motion, -52^{s} in α, and $5'$ northward.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed January 20.*

THE

ASTRONOMICAL JOURNAL.

No. 365.

VOL. XVI. BOSTON, 1896 FEBRUARY 3. NO. 5

ON BOSS'S SYSTEM OF DECLINATIONS AND ON THAT OF THE *ASTRONOMISCHE GESELLSCHAFT*,

By SIMON NEWCOMB.

I.

Boss's system of declinations, which has been adopted in the *American Ephemeris* since 1881, and which has formed the provisional basis of my work on the planetary theories, was completed in 1877, as a part of the Report of the U.S. Northern Boundary Commission. In constructing his work, the author adopted the plan, which had been so extensively carried out by AUWERS, of correcting the declinations of the various catalogues so as to reduce them to a mean homogeneous system. An additional improvement was made in regarding the mean system not merely as a constant, but as a quantity varying uniformly with the time. This course necessitated a division of the authorities into two classes, each having its own system of weights, the one class consisting of absolute determinations, which were used to form the mean system; the other of the catalogues which were not considered as available until they had been corrected for reduction to this system.

The list of authorities used in forming the mean system, with their respective weights, will be found on page 478 (72 of the Catalogue). The authorities for this system commence with BESSEL, for the date 1821, and end with Washington for the date 1872. I find the weighted mean epoch to be 1847.3.

It thus appears that the observations on which the fundamental system depends extend through only half a century. In view of the systematic errors which affect the best determinations of declination, even to this day, and of the very diverse elements used by the various authorities, especially the different constants of refraction, which Boss did not take account of, it might fairly be expected that the proper motions of the system would show systematic errors that would speedily make themselves felt. During the eighteen years which have elapsed since the work was published, data for detecting these errors have so accumulated that a good estimate of their probable amount may now be made.

The principal data in question are three in number.

1. AUWERS's re-reduction of BRADLEY's observations, which did not appear until after the publication of Boss's work.
2. The very accurate observations and discussions made since the appearance of Boss's work, especially those of Pulkowa and Greenwich.
3. My own work on the planetary theories, resulting in a determination of the magnitude of the mean error in the region of the equator, and of its secular variation.

II.

I propose to consider three classes of systematic differences between the Boss system and AUWERS–BRADLEY. First we investigate the general correction to the former in the equatorial zone. From the planetary theories (*Astronomical Constants*, page 89), I found the result,

$$\text{Correction} = +0''.09 + 0''.42\,T$$

T being the time from 1850, in terms of the century as unit.

The correction for the epoch 1850 I regard as quite reliable, and probably correct within ±0″.07. The secular term, however, is less reliable, owing to the difficulty of reducing the older observations to any one standard with entire certainty. I have therefore endeavored to test the result in other ways. The series of observations made on a uniform plan with the Greenwich Transit-Circle since 1851 ought to give, however weakly, some sort of a controlling result, because the most important systematic errors which they are affected with would probably remain unchanged throughout the series, especially when observations direct and by reflection are combined. In *Astronomical Papers*, Vol. II, page 447, I have given a result showing the apparent mean correction to Boss's equatorial system in zenith-distance south, and in polar-distances, for each year from 1851 to 1887, when the observations are all reduced on a uniform system. I prefer to take the polar-distances, rather than the zenith-distances, less from any belief in a progressive change in the latitude than from a possibility of systematic errors in the determination of the nadir-point.

The secular term to the correction of Boss's declinations which results from the table in question is

Cent. var. of correction = +0″.27.

We must admit, however, that the probable error of this quantity is fully equal to its whole amount.

I have obtained the same quantity by a comparison of the Pulkowa declinations for 1845 with those for 1885; an interval of forty years. To do this it was necessary to reduce them to the same absolute standard. In the Catalogue for 1885, Nyrén has changed the constant of refraction and the correction for temperature, as well as introduced a slight change in the latitude. It is therefore necessary to reduce the late catalogue to the same standard as the earlier one, by allowing for these changes. This is rendered very easy by a comparison which Nyrén gives in the Introduction to his last catalogue, page (2). I thus find, when both catalogues are reduced to the same standard, for the secular term in question,

+0″.45 *T*

Taking these results in connection with Boss's own work, which would give the value zero, I have reached the conclusion that the most probable secular term is

+0″.38 *T*

If the mean error of this result is estimated by the discordance among the eight separate results, it would be ±0″.09. But I think there is a fortuitous agreement between the separate results, and that the error may be as large as ±0″.30. Yet this would lead only to an error of ±0″.45 at the epoch 2000.

III.

The next class of systematic errors suggested by the comparison between Boss and Bradley is that depending upon the declination. In this and the next comparison I have availed myself of a very careful comparison of Boss's declinations, reduced to 1755, with those of Auwers–Bradley, which was made by Mr. Cleveland Keith, an Assistant in the Nautical Almanac Office, some years since. This work showed that the residuals, when arranged in the order of declination, were of a quasi-periodic character, which the computer found could be represented very closely, at least for stars of southern Z.D., by the corrections b_z found in Vol. II, page 252, of Auwers's work. These corrections were applied by Auwers to his declinations as printed and used, and the comparison with Boss showed that, had they not been applied, the periodic character of the deviations from Boss in question would not have been noticeable. Since Bradley's work did not enter at all into Boss's fundamental system, and entered with only a very small weight in the places of the separate stars, this result was of a nature to throw doubt on the reality of the corrections in question. Still, without other material than that afforded by the comparison, it would be difficult to reach a decisive conclusion on this subject. The most recent astronomical work will enable us to reach a conclusion, based on the following considerations.

If the corrections in question, as applicable to Boss's declinations in 1755, are real, then these declinations will be affected by a systematic error of the proper motion, of corresponding amount. The central epoch of Boss's work being 1847, the probable magnitude of the error thus introduced into the proper motions will be equal to the correction in question, divided by the elapsed interval, 92 years. The effect of this error upon the declinations in 1885 will be about 0.4 of the error in 1755, taken in the opposite direction. This quantity ought to be made evident by the recent Catalogues of Pulkowa and Greenwich.

On the other hand, if the corrections are unreal, the A.G. system will be affected by a corresponding error, though its amount will be smaller at the present time. The modern epoch for the A.G. system is about 1865. Hence in 1885 the error will be about one-fifth of its amount in 1755.

An examination of Auwers's table, *l.c.* page 252, shows that, within the zone 42° to 45°.5 of declination, the mean value of the correction in question was +1″.20, while within the zone 35° to 38° the mean value was −0″.50.

It will be better, however, instead of using these corrections, to take the actual differences between the catalogue places after they are applied. To show the case fully, I give the data for the individual stars contained in these two zones. The first column contains the corrections to Boss's declinations, as given by the printed results of Auwers in Vol. III of his work, where the corrections are applied. Next we have the corrections given by the four modern catalogues already mentioned at the several epochs from 1875 to 1890.

Zone A. +35°.4 to +38°.4.

	1755 Auwers	1875 Pulk.	1880 Greenw.	1885 Pulk.	1890 Greenw.
	″	″	″	″	″
ξ *Persei*	−0.5	+0.09	+0.22	+0.28	–
α *Lyncis*	−1.4	− .02	− .09	− .19	–
τ *Cygni*	−3.4	− .28	− .37	− .53	–
π *Herculis*	−2.1	+ .55	− .15	+ .44	–
μ *Andromedae*	−4.5	+ .41	+ .40	+ .54	+0.90
θ *Aurigae*	−1.3	+ .18	+ .06	− .09	–
θ *Herculis*	−1.4	− .53	− .70	− .76	–
ρ^2 *Herculis*	−2.5	− .05	+ .10	− .12	–
61^1 *Cygni*	−2.5	+ .33	− .34	− .05	−0.34
ρ *Persei*	−2.4	−0.49	+0.29	−0.08	–
Mean	−2.23	+0.02	−0.06	−0.06	+0.28

ZONE B. +42°.7 to +44°.9.

	1755 Auwers	1875 Pulk.	1880 Greenw.	1885 Pulk.	1890 Greenw.
	$''$	$''$	$''$	$''$	$''$
σ *Herculis*	+0.7	+0.12	+0.24	−0.09	–
ξ *Cygni*	+0.8	− .50	−0.59	− .32	–
κ *Andromedae*	−0.3	− .27	−1.01	− .53	–
χ *Herculis*	0.0	+0.43	+0.57	–	–
F.4 *Herculis*	+0.8	+1.01	+ .77	–	–
ε *Aurigae*	−0.1	0.00	–	− .01	–
λ *Ursae Maj.*	+1.7	− .04	+ .02	+ .07	–
α *Cygni*	−0.6	+ .03	− .36	+ .15	−0.14
δ *Cygni*	−0.4	− .06	+ .10	.00	–
β *Aurigae*	+0.1	−0.22	−0.08	+0.12	+0.04
Mean	+0.27	+0.05	−0.04	−0.08	−0.05

To show the bearing of these numbers upon the question, we remark that, rejecting entirely the proper motions found by Boss, we must give great weight to his declinations for the epoch 1847, which amounts to regarding their correction at that date as zero. Thus the corrections for the three epochs 1755, 1847 and 1880, ought to be consistent. The deviations from consistency are shown as follows:

	1755		1847	1880
	with Δz	without Δz		
	$''$	$''$		$''$
Zone A,	−2.23	−1.73	0	−0.02
Zone B,	+0.27	−0.93	0	−0.03
Difference,	+2.50	+0.80	0	−0.01

To the conclusions from considering each zone separately, it might be objected that I have applied no systematic corrections to the recent declinations. These corrections, however, should be nearly the same for the two zones, and therefore should be eliminated from their difference. I therefore show also the differential corrections, which it will be seen do not justify the large corrections applied by AUWERS.

IV.

The remaining class of well-marked differences between Boss and AUWERS–BRADLEY are those which depend upon the right-ascension. If this systematic difference were the same in all declinations, it might be difficult to reach a conclusion through a comparison with recent catalogues. But Mr. KEITH, in continuing his work, found that the periodic term depending on the right-ascension varied markedly with the declination. The mean result in the most well-marked cases is this:

Within the zone of declination +10° to +20° we have the mean periodic difference,

$$\text{BRADLEY–BOSS} = -0''.35\cos\alpha + 0''.04\sin\alpha$$

while within the zone +32° to +48° the corresponding periodic difference is

$$\text{BRADLEY–BOSS} = +0''.65\cos\alpha + 0''.02\sin\alpha$$

Reasoning in the same way as before, we find that if Boss's declinations really required these corrections in 1755, they should, in the year 1880, require the corrections

Zone +10° to +20°,	$+0''.13\cos\alpha - 0''.01\sin\alpha$
Zone +32° to +48°,	$-0''.24\cos\alpha - 0''.01\sin\alpha$
Difference,	$-0''.37\cos\alpha$

A comparison with the same catalogues as before, and a development of the difference in the above form, shows the following corrections to Boss given by those catalogues.

ZONE +10° to +20°.

Pulkowa, 1875,	$+0''.06\cos\alpha - 0''.04\sin\alpha$	wt. = 2
Greenwich, 1880,	$-0.03\cos\alpha + 0.00\sin\alpha$	" 2
Pulkowa, 1885,	$+0.03\cos\alpha - 0.04\sin\alpha$	" 3
Greenwich, 1890,	$+0.10\cos\alpha + 0.18\sin\alpha$	" 1
Mean,	$+0.03\cos\alpha + 0.00\sin\alpha$	

ZONE +32° to +48°.

Pulkowa, 1875,	$-0''.02\cos\alpha - 0''.03\sin\alpha$	wt. = 2
Greenwich, 1880,	$-0.11\cos\alpha - 0.04\sin\alpha$	" 2
Pulkowa, 1885,	$+0.07\cos\alpha + 0.05\sin\alpha$	" 3
Greenwich, 1890,	$+0.18\cos\alpha + 0.11\sin\alpha$	" 1
Mean,	$+0.02\cos\alpha + 0.02\sin\alpha$	

These means seem scarcely compatible with the reality of the AUWERS–BRADLEY corrections for 1755.

But it may be questioned whether these periodic terms may not be seriously affected by the neglect of the variation of latitude in the reductions, and whether, by allowing for this, their magnitude might not be changed by an amount sufficiently near to the value required to show the reality of the corrections in question.

How great soever this periodic term might be, it would not affect the difference of the errors for the two zones. Taking this difference, we have the resulting relative corrections,

1755,	$+1''.00\cos\alpha$
1847,	$0.00\cos\alpha$
1885,	$-0.01\cos\alpha$

The results for the two modern epochs seem incompatible with the reality of the correction in question for 1755. I therefore conclude that this difference also is mainly or entirely due to error of the BRADLEY declinations.

V.

The A.G. system is constructed by a comparison of the BRADLEY declinations with modern authorities, of which the mean epoch, as already stated, is about 1865. If the conclusions of the present investigation are correct, it follows that the proper motions of the A.G. system are affected by errors which from and after the year 1900 will reach a somewhat serious amount, quite unfitting it for use as a standard. Even before that time the corrections which it requires vary so rapidly within moderate limits of declination that its rigorous correction will not be a very simple process. The region within which the error is largest is that bounded by the parallels +34° and +39° of declination, and the circles 22^h and 2^h of right-ascension, including much of the constellation *Andromeda*. Here the maximum correction in 1755 seems to be about 3″.1, and the general mean correction about 2″.5. The systematic error of proper motion thus arising would, at the epoch 1900, cause an error requiring a correction of −0″.80. The following are the Pulkowa standard stars lying in or on the borders of the zone in question, and the corrections given by Nyrén to the declinations of the *Berliner Jahrbuch* for 1885.

Pulkowa 1885 — *B.J.*

	″
τ *Cygni*,	−0.49
27 *Pegasi*,	−0.64
π *Pegasi*,	−0.71
π *Andromedae*,	−0.01
μ *Andromedae*,	−0.31
β *Andromedae*,	−0.63
β *Trianguli*,	−0.06
ρ *Pegasi*,	−0.14

It fortunately happens that the zone-observations whose reductions are based on this system were not made at epochs so long after 1865 that the errors of the proper motions will cause serious trouble in reducing the declinations of these zones to such standard as in the future may seem to be best. If such reduction proves to be necessary in the refined work of the future, the comparative ease with which it can be made affords a yet stronger reason for regarding the A.G. system as only for temporary use.

NOTES ON VARIABLE STARS, — No. 11,

BY HENRY M. PARKHURST.

Results of Observations.

No.	Star	Phase	Observed Date		E	Corr.	W	Remarks
			Julian	Calendar				
5677	*R Serpentis*	Min.	3312	1895 Apr. 28	71	−21	1	See *A.J.* 308 and 333. Min. probably earlier
..	..	Max.	3453	Sept. 16	71	−31	9	Fluctuates near the maximum
5688	*R Librae*	Max.	3382:	July 7	19	−264	2	Not recognized in 1891; not looked for in 1893. Period 158.2 days?
5761	*Z Scorpii*	Max.	3426	Aug. 20	22	+24	5	Maxima sinking into the western twilight
5831	*S Scorpii*	Max.	3367	June 22	120	+ 1	3	
5887	*V Ophiuchi*	Min.	3355	June 10	26	–	4	Combined with *A.J.* 333 makes $M-m = 175$
5928	*T Ophiuchi*	Max.	3503	Nov. 5	36	–	0	Not seen in '92, '94, or '95. June to September, 11 dates
5950	*W Herculis*	Max.	3398	July 23	21	− 1	7	Descent slower than last year
6044	*S Herculis*	Max.	3398.5	July 23	46	+55	9	
6132	*R Ophiuchi*	Min.	2987:	June 7	45	–	–	1894, assumed midway
..	"	Max.	3404	July 29	46	−36	1	May have been earlier
6207	*Z Ophiuchi*	Min.	3455	Sept. 18	2	–	4	Elements, *A.J.* 347; makes $M-m = 208$
6512	*T Herculis*	Max.	3466.4	Sept. 29	61	+ 3	9	
6682	*X Ophiuchi*	Min.	3531	Dec. 3	11	+ 7	9	*A.J.* 319. By my elements, *A.J.* 311, corr. +3
6849	*R Aquilae*	Min.	3531	Dec. 3	43	+44	7	Secondary term still diminishing; see *A.J.* 311. Perhaps it is not too early to propose the provisional sine formula; 2399167 + 339.0 E + 106 sin 5°1 E
6894	*S Lyrae*	Max.	3525.3	Nov. 27	–	–	9	Period 439 days, probably not divisible
6903	*T Sagittarii*	Max.	3001	June 21	26	+162	2	From observations of 1894, *A.J.* 339
..	"	Max.	3384	July 9	27	+161	5	The min. in *A.J.* 339 probably two months too early. Period 439 days?
6921	*S Sagittarii*	Max.	3469	Oct. 2	46	− 8	9	Changes slow at maximum
(7010)	— *Sagittae*	–	–	–	–	–	–	Not seen in 1893, 1894, or 1895. August to November, 18 dates
7045	*R Cygni*	Max.	3405.5	July 30	35	− 3	9	
7085	*RT Cygni*	Max.	3386.0	July 11	15	+23	9	El., *A.J.* 319. Period from my obs., 191.3; see *A.J.* 311
..	"	Min.	3479.4	Oct. 12	16	+27	9	
7118	*X Aquilae*	Max.	3398	July 23	2	+ 2	5	Elements, *A.J.* 347. Probably obs. begun too late
7192	*Z Cygni*	Max.	3520	Nov. 22	12	− 2	9	Faint. Time consistent with last two max.
7234	*R Capricorni*	Max.	3477.5	Oct. 10	38	−22	9	Correction corresponds with preceding years
7252	*W Capricorni*	Max.	3511	Nov. 13	41	+11	5	Elements, *A.J.* 319
(7302)	— *Capricorni*	–	–	–	–	–	–	Nearly or quite constant. See following note

(7302). In the first reduction of my photometric observations, the assumed variable was omitted in fixing the standard. All the estimates having been comparisons with *Y* (SD. —16°5574), a doubt arose which was variable. The second reduction allowed half weight to *V* and *Y*. The third reduction, given in the table of observations, gives full weight to each of these stars. By the theory of probabilities each of these stars is as constant as the other comparison-stars employed. There is an apparent variation of half a magnitude, with a period of about fifty-four days, shown both in the estimates and in the photometric observations; on Oct. 17, *V* appearing 0M.26 fainter, and on Nov. 13 0M.27 brighter than *Y*, although this difference appears to be divided between the two stars. I think all the differences atmospheric, and the periodicity accidental. While the elimination of all possible bias in my method of photometric observation, extinguishing each star by itself, tends to confirm coincident results, on the other hand observations may be greatly affected by a changing sky without attracting attention, and inconsistent results must be received with caution.

Individual Observations.

5677 *R Serpentis.*

(Continued from 333.)

Julian	Calendar	Mag.
	1895	
3305.6	Apr. 21	12.8]
3307.6	23	13.1
3325.6	May 11	12.8
3337.6	23	12.6]
3342.6	28	12.6
3361.6	June 16	12.5
3423.5	Aug. 17	8.74_2
3434.6	28	7.02_2
3442.5	Sept. 5	6.29_2
3452.5	15	6.25_2
3457.6	20	6.66_2
3464.5	27	6.25_2
3468.5	Oct. 1	6.61_2
3470.6	3	6.70_2
3484.5	17	6.89_2

5688 *R Librae.*

	1894	
2983	June 3	11.6]
3013	July 3	11.7]
3038	28	11.6]
	1895	
3327.6	May 13	11.7]
3364.6	June 19	11.2
3370.6	25	10.5]
3385.6	July 10	10.6
3386.6	11	11.09_2
3403.6	28	11.7
3419.6	Aug. 13	12.1

5761 *Z Scorpii.*

(Continued from 333.)

3330.6	May 16	13 0
3342.6	28	12.8
3359.6	June 14	12.0
3385.6	July 10	11.0
3419.6	Aug. 13	10.8
3423.6	17	10.78_2
3427.5	21	10.44_2
3428.5	22	10.78_2
3429.5	23	11.10

5831 *S Scorpii.*

(Continued from 333.)

3330.6	May 16	12.7 :
3359.6	June 14	11.5
3365.6	20	10.69_2
3384.6	July 9	11.6
3387.6	12	10.94_2
3394.6	19	11.69_2

5887 *V Ophiuchi*

(Continued from 333.)

Julian	Calendar	Mag.
	1895	
3327.6	May 13	9.6
3342.6	28	9.6
3361.6	June 16	9.81_2
3384.6	July 9	9.36_2

5950 *W Herculis.*

(Continued from 333.)

3307.5	Apr. 23	12.0]
3337.6	May 23	11.3
3378.6	July 3	9.14_2
3385.6	10	8.60_2
3397.6	22	8.45_2
3401.6	26	8.54_2
3404.6	29	8.59_2
3408.6	Aug. 2	8.52_2
3416.6	8	8.78_2

6044 *S Herculis.*

(Continued from 333.)

3327.6	May 13	11.0
3351.6	June 6	10.50_2
3360.6	15	9.58_2
3368.6	23	9.20_2
3377.6	July 2	8.53_2
3385.6	10	8.03_2
3394.6	19	7.64_2
3398.6	23	7.19_2
3401.6	26	7.68_2
3404.6	29	8.04_2
3411.6	Aug. 5	7.58_2
3420.5	14	7.93_2

6132 *R Ophiuchi.*

	1894	
2983	June 3	12.7]
3000	20	12.5]
3013	July 3	12.9
3035	25	12.4
3047	Aug. 6	12.2
	1895	
3403.6	July 28	7.5
3404.6	29	7.15_2
3414.6	Aug. 8	7.56_2
3418.5	12	7.38_2
3424.5	18	7.70_2
3431.5	25	7.84_2
3441.5	Sept. 4	8.35_2

6207 *Z Ophiuchi.*

(Continued from 333.

3447.6	Sept. 10	10.7
3455.6	18	11.9

6207 *Z Ophiuchi*—Cont.

Julian	Calendar	Mag.
	1895	
3459.5	Sept. 22	11.1
3477.5	Oct. 10	11.1
3484.5	17	11.2
3491.5	24	10.8
3503.5	Nov. 5	10.9

6512 *T Herculis.*

(Continued from 333.)

3337.6	May 23	9.4
3419.6	Aug. 13	11.7
3429.6	23	10.70_2
3445.5	Sept. 8	9.77_2
3452.5	15	8.60_2
3459.5	22	7.78_2
3464.5	27	7.77_2
3467.6	30	7.96_2
3470.6	Oct. 3	7.76_2
3474.5	7	8.34_2
3484.5	17	8.38_2

6682 *X Ophiuchi.*

(Continued from 333.)

3449.6	Sept. 12	7.05
3465.5	28	7.74_2
3470.6	Oct. 3	7.35_2
3474.5	7	7.50_2
3485.5	18	8.14_2
3195.5	28	8.09_2
3501.5	Nov. 3	8.35_2
3511.5	13	8.35_2
3517.5	19	8.10_2
3525.5	27	8.99_2
3532.5	Dec. 4	8.94_2
3540.5	12	8.41_2
3550.5	22	9.08_2
3555.5	27	8.44_2

6849 *R Aquilae.*

(Continued from 339.)

3424.5	Aug. 18	9.17_2
3442.5	Sept. 5	9.90_2
3452.5	15	10.67_2
3464.5	27	10.46_2
3474.5	Oct. 7	11.00_2
3485.5	18	11.18_2
3490.6	23	11.15
3503.5	Nov. 5	11.72_2
3509.5	11	11.83_2
3516.5	18	11.89_2
3520.5	22	11.92_2
3533.5	Dec. 5	11.9

6849 *R Aquilae*—Cont.

Julian	Calendar	Mag.
	1895	
3540.5	Dec. 12	11.6]
3542.5	14	11.91_2
3550.5	22	11.38_2
3555.5	27	11.16_2

6894 *S Lyrae.*

(Continued from 339.)

3337.6	May 23	12.1]
3386.6	July 11	12.6]
3419.6	Aug. 13	12.8]
3451.6	Sept. 14	12.3]
3484.5	Oct. 17	12.2
3490.5	23	12.0
3509.6	Nov. 11	10.51_2
3513.5	15	10.38_2
3517.5	19	10.41_2
3520.5	22	10.08_2
3525.5	27	9.98_2
3531.5	Dec. 3	10.18_2
3533.5	5	10.36_2
3540.5	12	10.11_2
3550.5	22	10.73_2

6903 *T Sagittarii.*

(Continued from 339.)

3377.6	July 2	7.81_2
3384.6	9	7.3
3385.6	10	7.52_2
3387.6	12	7.63_2
3393.6	18	8.18_2

6921 *S Sagittarii.*

(Continued from 339.)

3425.5	Aug. 19	12.2 :
3447.6	Sept. 10	11.3
3448.6	11	11.45_2
3450.6	13	10.90_2
3452.5	15	11.21_2
3454.6	17	11.07_2
3455.5	18	10.86_2
3459.5	22	10.25_2
3464.5	27	10.28_2
3474.5	Oct. 7	10.22_2
3477.5	10	10.40_2
3481.5	14	10.21_2
3484.5	17	10.38_2

7045 *R Cygni.*

3378.6	July 3	7.59_2
3382.6	7	7.31_2
3384.6	9	6.82_2

7045 *R Cygni*—Cont.

Julian	Calendar	Mag.
	1895	
3386.6	July 11	6.61_2
3387.6	12	6.90_2
3393.6	18	7.01_2
3403.6	28	6.60_2
3404.6	29	6.78_2
3408.6	Aug. 2	6.72_2
3418.6	12	6.92_2
3429.6	23	7.38_2
3431.6	25	7.55_2

7085 *RT Cygni.*

(Continued from 339.)

3351.6	June 6	8.41_2
3352.6	7	8.46_2
3361.6	16	7.96_2
3368.6	23	7.54_2
3378.6	July 3	7.64_2
3382.6	7	7.49_2
3384.6	9	7.29_2
3386.6	11	7.04_2
3387.6	12	7.44_2
3393.6	18	7.80_2
3403.6	28	7.46_2
3404.6	29	7.75_2
3429.6	Aug. 23	9.4
3448.6	Sept. 11	11.3
3451.6	14	11.85_2
3455.6	18	11.76_2
3459.6	22	12.31_2
3464.5	27	12.67_2
3477.5	Oct. 10	12.72_2
3484.5	17	12.96_2
3490.6	23	12.98
3505.5	Nov. 7	11.8
3508.5	10	11.16_2
3511.5	13	10.84_2

7118 *X Aquilae.*

(Continued from 339.)

3394.6	July 19	9.88_2
3401.6	26	9.79_2
3403.6	28	10.10_2
3404.6	29	10.01_2

7192 *Z Cygni.*

(Continued from 339.)

3452.6	Sept. 16	12.2
3477.5	Oct. 10	10.5
3485.5	18	10.74_2
3495.5	28	9.79_2
3501.5	Nov. 3	10.02_2

7192 *Z Cygni* — Cont.

Julian	Calendar	Mag.
	1895	
3511.5	Nov. 13	9.52_2
3517.5	19	9.10_2
3519.5	21	9.00_2
3525.5	27	9.26_2
3531.5	Dec. 3	9.53_2
3540.5	12	10.09_2

7234 *R Capricorni.*

(Continued from 339.)

Julian	Calendar	Mag.
3449.6	Sept. 12	11.6
3450.5	13	12.08_2
3451.5	14	11.99_2
3454.5	17	12.11_2
3455.5	18	12.01_2
3459.5	22	12.23_2
3475.5	Oct. 8	11.8

7234 *R Capric.* — Cont.

Julian	Calendar	Mag.
	1895	
3477.5	Oct. 10	11.76_2
3484.6	17	11.81_2
3490.5	23	12.07
3503.5	Nov. 5	12.09_2
3509.5	11	12.03_2

7252 *W Capricorni*

(Continued from 339.)

Julian	Calendar	Mag.
3450.6	Sept. 13	13.4]
3455.6	18	13.2]
3475.5	Oct. 8	13.5
3477.5	10	13.22_2
3484.5	17	13.13_2
3490.5	23	12.5]
3502.5	Nov. 4	12.35
3509.5	11	12.14_2

7252 *W Capric.* — Cont.

Julian	Calendar	Mag.
	1895	
3513.5	Nov. 15	11.88_2
3516.5	18	12.28_2
3520.5	22	12.4

(7302) — *Capricorni.*

Julian	Calendar	Mag.
	1893	
2692	Aug. 16	10.7
2709	Sept. 2	10.4
2718	11	10.4
2742	Oct. 5	10.6
2766	29	10.4
2805	Dec. 7	10.5
	1894	
3017	July 7	10.6
3079	Sept. 7	10.3
3096	24	10.2
3131	Oct. 29	10.3

(7302) — *Capric.* — Cont.

Julian	Calendar	Mag.
	1894	
3153	Nov. 20	10.2
	1895	
3403	July 28	10.7
3428	Aug. 22	10.1
3455	Sept. 18	10.7
3478	Oct. 11	10.2
3481.5	14	10.38_2
3484.6	17	10.47_2
3485.5	18	10.33_2
3486.5	19	10.39_2
3487.5	20	10.31_2
3488.5	21	10.52_2
3490.5	23	10.30_2
3491.5	24	10.07_2
3495.5	28	10.18_2
3496.5	29	10.27_2

(7302) — *Capric.* — Cont.

Julian	Calendar	Mag.
	1895	
3497.5	Oct. 30	10.28_2
3499.5	Nov. 1	10.32_2
3501.5	3	10.28_2
3511.5	13	10.25_2

COMPARISON-STARS.

(7302) — *Capricorni.*

1 *W*	−16°5573	9.73	2
2 *W*	−16°5580	9.74	15
V	−16°5574	10.42	27
2 *V*	−16°5569	10.37	14
V 1*n*5*f* 2 *W*		10.31	28

OBSERVATIONS OF COMET *c* 1895 (*PERRINE*),

MADE AT THE BOSTON UNIVERSITY OBSERVATORY,

BY J. B. COIT AND G. E. WHITAKER.

1895 W. M. T.	*	No. Comp.	☄ − * $\Delta\alpha$	☄ − * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ	Obs.
			m s	′ ″	h m s	° ′ ″			
Nov. 27 17 7 39	1	6 , 6	−1 28.46	+7 29.8	14 14 20.35	− 5 13 56.8	*n*9.594	0.790	C
34 5	1	3 , 3*	−1 24.74	+6 26.8	14 14 24.07	− 5 14 59.8	*n*9.565	0.795	W
Dec. 3 17 17 13	2	6 , 4	−1 26.82	+2 27.7	14 43 29.61	−11 32 43.9	*n*9.597	0.807	C
6 17 38 12	3	6 , 5	−0 29.28	+6 52.5	15 6 0.71	−15 54 13.1	*n*9.594	0.820	C
18 8 21	4	3*	+0 13.24	. . .	15 6 12.93	. . .	*n*9.557	. .	C

*Stopped by twilight.

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	14 15 46.80	+2.01	− 5 21 9.6	−17.0	½ (W.B. XIV, 234 + Munich (1) 10063)
2	14 44 54.31	+2.12	−11 34 55.4	−16.2	Munich (2) 10619
3	15 6 27.80	+2.19	−16 0 50.1	−15.5	Munich (2) 11047
4	15 5 57.50	+2.19	−15 45 40.5	−15.5	Munich (2) 11033

OBSERVATIONS OF COMET *c* 1895 (*PERRINE*),

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY MARY W. WHITNEY.

1895 Greenwich M.T.	*	No. Comp.	☄ − * $\Delta\alpha$	☄ − * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ	Obs.
			m s	′ ″	h m s	′ ″			
Nov. 27 23 6 26	1	15	+2 49.27	. . .	14 14 27.59	. . .	*n*9.553	. . .	W
23 29.6	1	4	. . .	−0 51.5	. . .	− 5 16 19.8	. . .	0.792	F
Dec. 3 23 9 55	2	7	−1 14.96	+0 5.8	14 43 41.39	−11 35 9.6	*n*9.563	0.814	W

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	14 11 36.31	+2.01	− 5 15 11.2	−17.1	Gould, Gen. Catal. 19343
2	14 44 54.23	+2.12	−11 34 59.4	−16.0	Yarnall 6212

NOTE. — Through a failure of the chronograph, the time of the second observation could not be noted with much accuracy.

SUNSPOT OBSERVATIONS,

MADE AT PHILADELPHIA, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1895	Time	New Gps.	Total		Fac. Gps.	Def.
			Gps.	Spots		
July 1	9	–	4	10	1	fair
2	3	1	5	17	2	fair
3	8	1	5	16	3	fair
4	8	0	4	6	–	v.poor
5	12	–	4	9	1	poor
6	8	1	4	10	2	poor
7	9	1	5	22	3	fair
8	8	1	5	25	3	fair
9	8	1	6	40	2	fair
10	8	–	6	40	3	fair
11	8	1	4	38	2	poor
12	7	–	4	63	3	good
13	7	2	6	34	4	fair
14	7	–	6	36	4	fair
15	7	1	7	24	4	fair
16	3	–	4	11	2	poor
17	7	–	3	11	4	fair
18	7	–	3	6	3	poor
19	7	–	1	6	2	fair
20	7	2	3	14	2	fair
21	7	–	2	8	3	fair
22	7	1	3	11	3	fair
23	7	1	1	7	3	fair
24	7	1	2	5	2	fair
25	8	–	1	1	2	poor
26	7	1	3	12	4	fair
27	3	–	3	18	–	poor
28	8	–	3	33	4	fair
29	8	1	3	24	3	fair
30	8	1	3	25	2	fair
31	8	–	3	52	3	good
Aug. 1	8	3	5	53	2	good
2	8	1	6	63	3	good
3	8	–	6	64	3	good
4	9	2	6	110	2	good
5	6	–	6	54	1	poor
* 6	7	–	6	42	–	poor
* 7	7	–	6	88	1	fair
* 8	7	–	6	72	1	fair
* 9	7	–	5	31	–	poor
*10	7	–	4	58	1	fair
*11	7	–	5	46	3	fair
*12	5	–	6	45	2	fair
*13	4	–	5	12	2	poor
*14	6	–	5	14	3	poor
*15	8	–	4	12	2	poor
*16	7	–	3	24	2	fair
*17	6	–	3	20	1	fair
*18	5	–	2	28	1	poor
*19	6	–	2	30	1	poor
*20	7	–	2	25	1	poor
*21	7	–	2	19	1	poor
*22	8	–	2	12	1	poor
23	9	–	2	19	3	fair
24	2	2	4	26	3	fair
Aug. 25	8	2	6	32	3	fair
26	6	–	4	15	2	poor
27	9	1	4	8	1	poor
28	8	–	3	18	3	fair
29	8	–	3	11	3	fair
30	8	–	3	30	3	fair
31	2	1	4	23	2	fair
Sept. 1	8	–	4	12	2	fair
2	8	1	5	24	2	fair
3	8	–	5	29	2	fair
4	8	1	6	24	2	fair
5	10	–	4	19	2	poor
6	2	2	5	16	2	poor
8	8	–	5	33	4	fair
9	8	–	4	17	2	poor
10	8	1	4	10	2	poor
11	8	–	2	8	3	poor
12	8	3	7	30	5	fair
14	10	–	3	23	2	fair
15	8	–	3	28	3	fair
16	8	1	4	20	3	poor
17	8	1	3	18	3	poor
18	12	–	2	10	2	poor
19	10	–	2	9	2	poor
20	10	2	3	16	3	poor
21	8	1	3	19	3	poor
22	8	–	3	18	4	fair
23	8	–	3	18	4	fair
24	8	–	3	15	3	fair
25	8	1	4	11	3	fair
26	8	2	6	26	3	fair
27	8	–	6	45	3	fair
28	7	–	6	56	3	fair
29	9	–	6	54	1	fair
30	8	1	7	78	1	fair
Oct. 1	9	–	7	106	2	fair
2	9	–	7	234	2	good
3	7	–	6	107	1	poor
*4	7	–	6	68	1	poor
5	4	–	5	73	4	poor
6	8	–	5	104	3	poor
7	10	–	3	40	1	poor
8	3	–	2	22	2	poor
9	8	–	4	21	2	poor
10	10	–	2	10	2	poor
11	9	–	2	6	3	poor
14	9	1	2	9	3	poor
15	9	1	2	7	3	poor
16	9	–	2	10	1	poor
17	12	–	1	4	1	poor
18	9	–	1	6	3	fair
19	8	1	2	5	3	poor
20	9	–	2	16	2	poor
21	9	2	4	25	3	poor
Oct. 22	9	–	3	50	4	poor
23	9	1	4	56	4	poor
24	9	1	5	128	3	fair
25	9	–	5	91	2	poor
26	9	–	4	69	2	poor
27	9	–	4	62	1	poor
28	3	–	5	55	3	fair
29	8	1	6	44	2	poor
30	8	–	6	91	3	good
Nov. 1	9	1	6	90	3	fair
3	9	1	6	64	3	fair
4	9	–	5	75	2	fair
5	9	–	4	50	3	poor
7	9	–	3	20	2	poor
9	11	–	1	5	3	poor
11	3	1	1	3	2	poor
12	9	–	1	3	2	poor
13	2	1	2	13	3	fair
15	9	2	4	11	1	poor
16	12	–	4	10	1	fair
18	1	1	4	13	2	fair
19	12	2	5	13	2	fair
21	10	–	4	8	1	fair
22	9	2	6	12	2	fair
23	9	–	5	9	2	fair
27	9	–	4	7	2	fair
28	9	–	4	12	1	fair
29	9	–	4	9	2	fair
30	9	–	1	3	1	poor
Dec. 1	1	–	1	2	1	poor
2	3	2	3	13	–	poor
3	9	–	3	20	1	poor
4	8	–	2	12	1	poor
5	2	2	6	21	3	poor
6	1	2	5	16	3	poor
7	12	1	5	7	–	poor
11	10	3	6	44	1	fair
12	12	–	5	38	1	fair
13	12	2	7	21	1	poor
14	1	–	7	32	1	poor
15	9	–	5	19	1	poor
16	9	1	7	25	2	fair
17	9	–	7	17	3	poor
18	10	–	7	46	3	fair
19	10	–	5	32	3	poor
20	2	1	5	26	1	fair
21	10	2	7	46	1	fair
22	9	–	6	47	2	fair
23	9	–	7	54	1	fair
24	9	–	7	43	1	fair
25	12	–	6	26	1	poor
27	10	2	8	24	4	poor
29	9	–	3	14	2	poor
31	10	1	4	16	2	poor

*2½-inch refractor.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER AT GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY H. C. WILSON.

[Communicated by the Director, WM. W. PAYNE.]

1895 Northfield M.T.		∗	No. Comp.	☄ − ∗ Δα	☄ − ∗ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
				Comet *a* 1895 (Swift).					
Dec. 6*	8 38 33 h m s	1	11 , 5	−2 15.20 m s	+2 21.1 ′ ″	1 47 37.45 h m s	+ 5 58 7.8 ° ′ ″	*n*8.082	0.738
7	7 57 23	2	11 , 6	−0 8.23	−1 35.4	1 48 26.50	+ 6 4 56.2	*n*8.914	0.738
				Comet *d* 1895 (Brooks).					
Dec. 17	11 52 31	4	3 , 2	−4 51.07	−1 38.5	5 37 3.62	+66 49 17.7	8.107	*n*0.530
	11 53 31	5	9 , 6	−1 50.57	−3 45.5	5 37 2.59	+66 49 13.7	. . .	. . .

Mean Places for 1895.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
1	1 49 48.51 h m s	+ 4.11 s	+ 5 55 20.7 ° ′ ″	+26.0 ″	Schjellerup 561
2	1 48 30.60	+ 4.13	+ 6 6 5.6	+26.0	Micrometer-comparison with ∗3
3	1 45 22.60	+ 4.11	+ 6 8 24.4	+26.1	Bonn Obs., VI, +5°250
4	5 41 44.57	+10.12	+66 50 46.1	+10.1	Fearnley, Christiania A.G. Catal., 938
5	5 38 43.05	+10.11	+66 52 48.6	+10.6	Fearnley, Christiania A.G. Catal., 931

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* The declination is a little uncertain on Dec. 6, because the times of some of the bisections failed of record on the chronograph. The error from this source cannot, however, be greater than 5″.

EPHEMERIS OF VARIABLES OF THE *ALGOL*-TYPE,

Greenwich Mean Time.

BY PAUL S. YENDELL.

		h
1896 February		
3	Algol	13
6	Algol	10
	U Cephei	12
	U Ophiuchi	20
7	*U* Ophiuchi	16
8	δ Librae	19
9	*R* Canis Maj.	15
10	*R* Canis Maj.	19
	λ Tauri	22
11	*U* Cephei	11
	U Ophiuchi	21
12	*U* Ophiuchi	17
14	λ Tauri	21
15	*S* Cancri	16
	δ Librae	19
16	*U* Cephei	11
17	*R* Canis Maj.	14
	U Ophiuchi	18
	Algol	21
18	*U* Ophiuchi	14
	R Canis Maj.	17
	λ Tauri	19
19	*U* Coronae	20
	R Canis Maj.	21
20	Algol	18
21	*U* Cephei	11
22	λ Tauri	18
	δ Librae	19
23	Algol	15
26	*U* Cephei	10
	Algol	11
	R Canis Maj.	16
	λ Tauri	17
26	*U* Coronae	18
27	*U* Ophiuchi	14
29	Algol	8
	δ Librae	18
1896 March		
1	λ Tauri	16
3	*R* Canis Maj.	9
	U Ophiuchi	19
4	*R* Canis Maj.	12
	U Ophiuchi	16
4	*U* Coronae	16
	U Cephei	22
5	λ Tauri	15
	R Canis Maj.	15
	S Cancri	15
6	*R* Canis Maj.	18
7	*U* Cephei	10
	δ Librae	18
9	λ Tauri	14
	U Ophiuchi	17
	U Cephei	21

NEW ASTEROIDS.

Prof. KREUTZ has communicated notice of the discovery of two additional asteroids, by Prof. WOLF, at Heidelberg. Their positions at Heidelberg midnight 1896 Jan. 7.

CK 11^{M} $\alpha = 6^{h}\,56^{m}\,56^{s}$, $\delta = +22^{\circ}\ 2'$. Daily motion, -48^{s} in α. and $3'$ northward.
CL 12^{M} $\alpha = 6^{h}\,56^{m}\,16^{s}$, $\delta = +22^{\circ}\ 36'$. Daily motion. -48^{s} in α, and $4'$ northward.

Also, of two found by Mr. CHARLOIS, Jan. 16, and observed as follows:

CM 13^{M} Jan. 17 $9^{h}\,31^{m}.8$ Nice M.T. $\alpha = 8^{h}\,33^{m}\,58^{s}$, $\delta = +23^{\circ}\,9'\,33''$. Daily motion, -60^{s} in α, and $4'$ northward.
CN $13^{M}.2$ " $9^{h}\,59^{m}.0$ " " $\alpha = 8^{h}\,38^{m}\,30^{s}$. $\delta = +21^{\circ}\,2'\,50''$. Daily motion, -48^{s} in α, and $6'$ northward.

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ON BOSS'S SYSTEM OF DECLINATIONS AND ON THAT OF THE ASTRONOMISCHE GESELLSCHAFT, BY PROF. SIMON NEWCOMB.
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OBSERVATIONS OF COMET *c* 1895 (PERRINE), BY MISS MARY W. WHITNEY.
SUNSPOT OBSERVATIONS, BY REV. A. W. QUIMBY.
OBSERVATIONS OF COMETS, BY DR. H. C. WILSON.
EPHEMERIS OF VARIABLES OF THE ALGOL-TYPE, BY MR. PAUL S. YENDELL.
NEW ASTEROIDS.

PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed February 3.*

THE
ASTRONOMICAL JOURNAL.
No. 366.

VOL. XVI. BOSTON, 1896 FEBRUARY 17. NO. 6

RESEARCHES ON THE ORBIT OF F.99 *HERCULIS* = A.C.15.

By T. J. J. SEE.

This difficult double star was discovered by Alvan Clark, while testing an instrument he had made for Dawes, at the latter's private observatory, July 10, 1859. During the same year the object was carefully measured by Dawes on two nights. Otto Struve began to give his attention to the pair the following year, and continued his measures from time to time until 1888. His first observations are very satisfactory, and of the highest value in fixing the elements of the orbit; but the later measures are less trustworthy, owing to the great inequality and closeness of the components. The series of measures begun by Burnham in 1878 and continued until the close of his work in California is of great importance and in conjunction with Struve's observations and those recently made by the writer at Madison, enables us to fix the elements with a relatively high degree of precision. The following is a complete list of the observations of F.99 *Herculis*:

	°	″		
1859.61	347.4	1.61	1*n*	Dawes
1859.65	347.0	1.80	1*n*	Dawes
1860.30	342.3	2.28	1*n*	O. Struve
1866.68	360.8	1.73	1*n*	O. Struve
1868.50	358.6	1.69	1*n*	O. Struve
1872.56	6.0	1.46	1*n*	O. Struve
1877.56	22.0	1.19	1*n*	O. Struve
1878.46	24.4	1.09	3–1*n*	Burnham
1879.47	26.5	1.13	1*n*	Burnham
1880.53	31.6	0.90	2-1*n*	Burnham
1881.43	29.4	0.51	1*n*	Burnham
1883.60	72.9	1.30	1*n*	O. Struve
1883.70	82.4	1.04	1*n*	O. Struve
1888.54	77.4	1.05	1*n* Diff.	O. Struve
1889.50	281.2	0.65	1*n*	Burnham
1890.45	285.1	0.59	3–2*n*	Burnham
1891.56	292.0	0.72	2–3*n*	Burnham
1892.40	299.2	0.70	3*n*	Burnham
1894.74	305.7	0.88	1*n*	Comstock
1895.50	308.0	0.95	2*n*	See
1895.73	315.2	1.12	3*n*	See

In order to obtain a good orbit from such measures the means must be formed in a judicious manner, regard being had to the known motion of the companion. After careful study of all the observations, I have formed a suitable set of mean places, and deducted the corresponding elements. The orbits previously found for this system are:

	Gore, 1890 *M.N.*, Nov. 1893	See, 1895 unpublished
P	$53^y.55$	$57^y.5$
T	1885.58	1887.30
e	0.7928	0.806
a	1″.12	1″.163
☊	50°.1	77°.0
i	38°.6	35°.5
λ	110°.73	90°.0

The adopted elements of F.99 *Herculis* are as follows:—

P = 54.5 years
T = 1887.70
e = 0.781
a = 1″.014
☊ = indeterminate
i = 0°.0
Angle of periastron = 169°.5
n = +6°.6055

The apparent is the same as the real orbit.

Length of major axis = 2″.028
Length of minor axis = 1″.278
Angle of major axis and periastron = 169°.5

The following table shows the agreement of the computed with the observed places.

Comparison of Computed with Observed Places.

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
1859.65	347.0	348.4	1.80	1.81	− 1.4	−0.01	1	Dawes
1859.96	341.8	348.9	1.94	1.81	− 4.1	+0.13	2	Dawes, 1; O. Struve, 1
1866.68	360.8	357.8	1.73	1.74	+ 3.0	−0.01	1	O. Struve
1868.50	358.6	360.5	1.69	1.70	− 1.9	−0.01	1	O. Struve
1872.56	6.0	7.0	1.46	1.56	− 1.0	−0.10	1	O. Struve
1877.56	22.0	17.4	1.19	1.29	+ 1.6	−0.10	1	O. Struve
1878.46	21.1	20.1	1.04	1.21	+ 1.3	−0.17	3–1	Burnham
1879.17	26.5	23.2	1.13	1.14	+ 3.3	−0.01	1	Burnham
1880.53	31.6	27.3	0.90	1.04	+ 4.3	−0.14	2–1	Burnham
1881.43	29.4	31.0	0.77	0.96	− 1.6	−0.19	1–2	Burnham, 1; O. Struve, 0–1
1889.50	257.4	262.7	0.65	0.42	− 5.3	+0.23	1–1	Burnham, 0–1; O. Struve, 1–0
1890.45	285.1	280.5	0.59	0.56	+ 4.6	+0.03	3–2	Burnham
1891.56	292.0	292.9	0.72	0.71	− 0.9	+0.01	2–3	Burnham
1892.40	299.2	299.2	0.70	0.80	0.0	−0.10	3	Burnham
1894.74	305.7	311.3	0.88	1.04	− 5.6	−0.16	1	Comstock
1895.50	308.0	314.2	0.95	1.11	− 6.2	−0.16	2	See
1895.73	315.2	315.1	1.12	1.13	+ 0.1	−0.01	3	See

While this orbit may need slight modification in the course of time, it does not seem probable that a sensible improvement can be effected for a good many years, as the motion is now very slow, and chiefly in the direction of the radius vector. The orbit is remarkable for its high eccentricity, and for having no sensible inclination. This circumstance enables us to contemplate directly the real orbit, and renders F.99 *Herculis* an object of the highest interest. If observations could be made sufficiently exact, the motion of the apparent radius vector would give us a means of proving the law of universal gravitation by direct observation. The pair is always rather difficult, owing to the inequality of the components, and exact measurement is seldom possible. But at present the star is relatively easy, and ought to be given some attention by observers. The following is a short ephemeris:

1896.50	317°.5	1″.18
1897.50	320.4	1.26
1898.50	323.0	1.33
1899.50	325.3	1.39
1900.50	327.6	1.45

The University of Chicago, 1895 *October* 9.

REPLY TO MR. DYSON'S NOTE ON PHOTOGRAPHIC REFRACTIONS IN *A.J.* 354,

By HAROLD JACOBY.

In the above note Mr. Dyson comes to the conclusion that Prof. Turner's formulas (*Monthly Notices, R.A.S.*, 1893 November) are correct. Prof. Turner gives the following formulas for computing differences of right-ascension and declination from rectangular coordinates measured on the plate.

$$(a)\qquad \left\{\begin{aligned} q &= P-\tan^{-1}\eta \\ \tan(\alpha-A) &= \frac{\xi\cos(P-q)}{\sin q} \\ \tan p &= \tan q\,\sec(\alpha-A) \end{aligned}\right.$$

in which q is an auxiliary. Prof. Turner also gives formulas for computing $d\xi$ and $d\eta$, which he states to be the differential refraction-corrections required by ξ and η respectively.

If we compute α and p by means of the above formulas directly from the measured coordinates ξ and η, we shall get the *apparent* α and p of the star. If we compute by the same formulas, using instead of ξ and η, $\xi+d\xi$ and $\eta+d\eta$, we shall get the true α and p of the star, if the formulas for $d\xi$ and $d\eta$ are right. Now the above formulas admit of being expanded into series, which is convenient for my present purpose. We find (*b*)

$$\left.\begin{aligned} (\alpha-A)\sin P &= \xi+\xi\eta\cot P+\xi\eta^2\cot^2P-\tfrac{1}{3}\xi^3\operatorname{cosec}^2P+\ldots \\ p-P &= -\eta+\tfrac{1}{2}\xi^2\cot P+\tfrac{1}{2}\xi^2\eta\operatorname{cosec}^2P+\tfrac{1}{3}\eta^3+\ldots \end{aligned}\right\}$$

These formulas are equivalent to Prof. Turner's rigorous formulas (*a*) above; and as I have just stated, they should hold true:

1. For computing $(\alpha-A)\sin P$ and $(p-P)$ from ξ and η.

2. For computing $\{(\alpha-A)\sin P+d[(\alpha-A)\sin P]\}$ and $[(p-P)+d(p-P)]$ from $\xi+d\xi$ and $\eta+d\eta$, where $d[(\alpha-A)\sin P]$ and $d(p-P)$ are the differential refraction corrections required by $(\alpha-A)\sin P$ and $(p-P)$.

Now we see from the expansions (*b*) that $(\alpha-A)\sin P$ and $(p-P)$ differ from ξ and $-\eta$ respectively by small quantities of the second order only. Also, $d\xi$ and $d\eta$, being differential refractions, are small quantities of the second order. Consequently, $d[(\alpha-A)\sin P]$ and $-d(p-P)$

can differ from $d\xi$ and $d\eta$ only by very small quantities of the third order, which are here negligible, as they will never exceed one or two-hundredths of a second of arc.

From the above demonstration we see that if we intend to use Prof. Turner's formulas (a) or their equivalent (b), to transform our corrected coordinates $\xi + d\xi$ and $\eta + d\eta$ into α and p, we must use values of $d\xi$ and $d\eta$, that satisfy the condition,

$$d\xi = d\left[(\alpha - A)\sin P\right] \quad , \quad d\eta = -d\,(p-P)$$

If therefore Mr. Dyson wishes to use Prof. Turner's refraction-formulas as they stand, he must allow for the terms by which they differ from mine in the transformation formulas (a) or (b). There can be no doubt that Prof. Turner's refraction and transformation-formulas used together give an erroneous result. One or the other must be changed.

The matter seems to me so important, that I have tested the formulas under consideration by means of a fictitious numerical example.

I begin by assuming that a plate has been made in a place whose latitude is 55°, such that

R.A. of center $= A = 0°\ 0'\ 0''.00.$
Polar distance of center $= P = 30°\ 0'\ 0''.00.$
Hour angle of center $= t = 45°\ 0'\ 0''.00.$

I assume that we have measured on this plate the rectangular coordinates of a star, and found them to be

$$\xi = +60'.0000 \quad , \quad \eta = +60'.0000$$

To these values of ξ, η and P, I have applied Prof. Turner's formulas of transformation. viz.:

$$\begin{aligned} q &= P - \tan^{-1}\eta \\ \tan(\alpha - A) &= \xi \cos(P-q)\operatorname{cosec} q \\ \tan p &= \tan q \sec(\alpha - A) \end{aligned}$$

and I find for the polar-distance and right-ascension of the star,

$$p = 29°\ 0'\ 57''.00 \quad , \quad \alpha = +2°\ 3'\ 41''.24$$

I think no one will question that these values of α and p are the *apparent* coordinates of the star, by which I mean the actual coordinates of the star as we see it on the sky, affected by refraction. provided the above values of A and P are also apparent. And I here explicitly assume that such is the case. In other words, I assume that if there were a star in the sky whose apparent R.A. and Decl. were exactly 0° and 60°. that star would appear exactly in the center of the plate.

Being now in possession of the apparent positions of the center and the star, we can readily obtain the *true* positions. The formulas for doing this are contained in the first volume of Chauvenet, and are there numbered (20) and (234). These formulas are as follows:

$$\begin{aligned} \tan N &= \cot\varphi \cos t \\ \tan\zeta \sin q &= \frac{\tan t \sin N}{\sin(\delta + N)} \\ \tan\zeta \cos q &= \cot(\delta + N) \end{aligned} \tag{20}$$

$$\begin{aligned} d\delta &= -k' \tan\zeta \cos q \\ \cos\delta\, d\alpha &= -k' \tan\zeta \sin q \end{aligned} \tag{234}$$

I have applied these formulas separately to the center and the star, using the following values for the quantities entering the formulas.

For the center	For the star
$k' = 57''$	$k' = 57''$
$\varphi = 55°\ 0'$	$\varphi = 55°\ 0'$
$t = 45°\ 0'$	$t = 42°\ 56'$
$\delta = 60°\ 0'$	$\delta = 60°\ 59'$

I thus find the following corrections for refraction, which are additive to the apparent R.A. and δ.

For the center	For the star
$d\alpha = -50''.68$	$d\alpha = -49''.88$
$d\delta = -\ 3''.65$	$d\delta = -\ 1''.88$

Applying these quantities to the apparent positions of the star and center gives

		°	′	″
True α of center	=	359	59	9.32
True p of center	=	30	0	3.65
True α of star	=	2	2	51.36
True p of star	=	29	0	58.88

Having thus obtained the true and apparent positions of the center and of the star, we are now ready to test any differential-refraction formulas. To avoid the possibility of misunderstanding, it will be well to state the problem again.

Suppose we have measured the rectangular coordinates of a star upon the plate, and found them to be

$$\xi = +60'.0000 \quad , \quad \eta = +60'.0000$$

It is required to correct these measured coordinates by means of differential-refraction formulas, and with their values, so corrected, to compute the true position of the star. The elements of the plate are,

Apparent position of center is

R.A. $= 0°\ 0'\ 0''.00$, N.P.D. $= 30°\ 0'\ 0''.00$

True position of center is

R.A. $= 359°\ 59'\ 9''.32$, N.P.D. $= 30°\ 0'\ 3''.65$

I begin by testing Prof. Turner's formulas, and will first compute his values of the differential-refraction. The formulas for doing this I take from the *Monthly Notices, R.A.S.*, Vol. 54, p. 14. The formulas, with slight changes of notation, are

$$\begin{aligned} \tan q &= \cot\phi \cos t \\ X &= \frac{\tan t \sin q}{\cos(P-q)} \\ Y &= \tan(P-q) \\ d\xi &= k'\{(1+X^2)\,\xi + XY\eta\} \\ d\eta &= k'\{XY\xi + (1+Y^2)\,\eta\} \end{aligned}$$

Using in these formulas the quantities belonging to the center, viz.:

$\varphi = 55°\ 0'$ $\qquad t = 45°\ 0'$
$P = 30°\ 0'$ $\qquad k = 57''$

I find the following results:

$$\log X = 9.6179 \qquad \log Y = 8.8067$$
$$d\xi = +0'.0203 \qquad d\eta = +0'.0171$$

and consequently we have for the corrected rectangular coordinates, the values,

$$\xi = +60'.0203 \quad . \quad \eta = +60'.0171$$

With these corrected values of the coordinates we ought to be able to compute the true place of the star, by means of the same transformation formulas as before, namely:

$$\begin{aligned} q &= P - \tan^{-1}\eta \\ \tan(\alpha - A) &= \xi \cos(P - q) \operatorname{cosec} q \\ \tan p &= \tan q \sec(\alpha - A) \end{aligned}$$

In using these formulas for the present purpose, the question arises as to what value of P ought to be employed. We might use the polar distance of the center, either corrected for refraction, or not so corrected. In my opinion, the uncorrected value of P should be used, because this is the actual angular distance from the pole of the heavens to the point where the tangency of the plate actually exists. But the use of the true or corrected value of P would produce no material difference. The results obtained by the above transformation formulas are

$$\text{True}(\alpha - A) = +2^\circ\, 3'\, 13''.82 \; . \; \text{True}(p - P) = -0^\circ\, 59'\, 3''.98$$

Adding to these numbers the known true coordinates of the center, viz.:

$$\text{True } A = 359^\circ\, 59'\, 9''.32 \quad , \quad \text{True } P = 30^\circ\, 0'\, 3''.65$$

we obtain for the true position of the star,

$$\text{True } \alpha = 2^\circ\, 2'\, 53''.11 \quad , \quad \text{True } p = 29^\circ\, 0'\, 59''.67$$

Comparing these with the values of the same numbers obtained from CHAUVENET's formulas, which were

$$\text{True } \alpha = 2^\circ\, 2'\, 51''.36 \quad . \quad \text{True } p = 29^\circ\, 0'\, 58''.88$$

we find the errors caused by Prof. TURNER's formulas to be

$$\text{Error of } \alpha = 1''.78 \quad , \quad \text{Error of } p = 0''.79$$

I have also applied my formulas for differential refraction to the same example. These formulas, as printed by Mr. DYSON in *A.J.*, no. 354, p. 151, are

$$\begin{aligned} d\xi &= k'\xi\{(1 + X^2) - Y \cot P\} + k'\eta\{XY - X \cot P\} \\ d\eta &= k'\xi\{XY + X \cot P\} + k'\eta\{1 + Y^2\} \end{aligned}$$

X and Y having the same numerical values as in Prof. TURNER's formulas. Computing by these, I find

$$d\xi = +0'.0057 \quad , \quad d\eta = +0'.0299$$

so that the corrected values of the rectangular coordinates are

$$\xi = +60'.0057 \quad . \quad \eta = +60'.0299$$

With these values of the corrected coordinates I have computed the transformation formulas, in precisely the same way as in the case of Prof. TURNER's formulas, and I find

$$\text{True}(\alpha - A) = 2^\circ\, 3'\, 12''.01 \; . \; \text{True}(p - P) = -0^\circ\, 59'\, 4''.79$$

To these numbers I have added the true coordinates of the center, which are as before,

$$\text{True } A = 359^\circ\, 59'\, 9''.32 \quad , \quad \text{True } P = 30^\circ\, 0'\, 3''.65$$

I thus get for the true position of the star,

$$\text{True } \alpha = 2^\circ\, 2'\, 51''.33 \quad , \quad \text{True } p = 29^\circ\, 0'\, 58''.86$$

whereas the values from CHAUVENET's formulas were

$$\text{True } \alpha = 2^\circ\, 2'\, 51''.36 \quad . \quad \text{True } p = 29^\circ\, 0'\, 58''.88$$

The agreement is almost exact, and the correctness of my differential formulas seems to be established.

Columbia College Observatory, New York, 1896 January.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE DUDLEY OBSERVATORY,

BY A. JAY ROY.

1895 Albany M.T.		$*$	No. Comp.	Planet − $*$ $\Delta\alpha$	Planet − $*$ $\Delta\delta$	Planet's apparent α	Planet's apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
					(313) Chaldaea.				
	h m s			m s	′ ″	h m s	° ′ ″		
Sept. 19	11 11 10	23	12	+2 32.30	− 6 30.4	1 37 15.92	+ 4 17 23.5	n9.341	0.742
20	9 42 34	24	10	+0 13.15	− 0 11.4	36 45.68	4 8 45.5	n9.571	0.756
21	10 56 2	25	9	−0 39.04	+ 4 21.6	36 9.60	3 58 45.8	n9.440	0.748
22	8 56 14	26	10	+1 9.49	− 2 17.0	35 37.27	+ 3 49 59.2	n9.606	0.762
Oct. 18	7 52 2	27	10	−1 3.05	+ 3 21.1	15 5.58	− 0 37 53.4	n9.513	0.779
21	8 5 1	28	8	−1 59.99	− 3 47.8	12 30.13	1 6 57.7	n9.500	0.782
23	7 57 54	29	8	+1 17.88	+ 6 11.0	10 49.28	1 25 30.7	n9.495	0.784
24	9 14 56	29	10	+0 25.40	− 3 18.2	1 9 56.81	− 1 34 59.9	n9.273	0.787
					(103) Hera.				
Oct. 21	9 5 15	30	8	+1 11.96	+ 5 1.8	2 58 57.55	+ 8 9 5.2	n9.571	0.734
23	8 26 39	30	8	+0 6.92	− 4 22.3	57 22.55	7 59 38.1	n9.601	0.743
Nov. 11	8 51 36	31	10	−1 34.89	− 1 17.0	40 50.30	6 39 42.0	n9.414	0.725
13	9 9 17	32	8	+2 9.83	+ 0 55.2	39 8.30	6 33 10.8	n9.334	0.722
16	6 49 30	33	8	+0 7.13	− 1 39.5	36 14.38	6 21 37.9	n9.583	0.746
19	7 57 54	34	8	+3 56.26	− 6 33.5	34 20.10	6 16 58.8	n9.152	0.731
21	9 12 59	34	7	+2 23.66	−10 57.5	2 32 17.51	+ 6 12 34.8	n9.156	0.721

1895 Albany M.T.		*	No. comp.	Planet — * Δα	Planet — * Δδ	Planet's apparent α	Planet's apparent δ	log pΔ for α	log pΔ for δ
				(175) *Andromache.*					
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 11	9 37 10	35	10	+1 53.98	+ 5 47.5	4 58 21.00	+25 43 40.3	n9.618	0.594
12	9 6 35	36	10	−0 45.00	+ 2 59.5	57 37.00	43 31.9	n9.643	0.625
16	7 40 56	37	8	+1 18.97	− 4 7.4	54 33.76	42 50.8	n9.680	0.700
19	9 0 48	38	10	−1 11.44	+ 2 29.7	52 1.82	41 32.4	n9.616	0.593
Dec. 9	10 44 35	39	2	+3 1.49	− 9 52.8	34 5.74	21 18.4	n8.865	0.420
10	9 59 36	39	6	+2 10.62	−11 19.7	33 14.88	19 51.5	n9.191	0.440
14	8 1 28	40	6	−3 9.65	+12 55.2	29 54.53	13 47.9	n9.520	0.530
22	8 4 34	41	10	−2 22.70	+ 2 45.4	23 41.20	0 43.6	n9.422	0.492
22	8 52 25	42	6	−2 42.29	+ 6 28.5	4 23 39.51	+25 0 37.7	n9.244	0.453

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
23	1 34 39.99	+3.63	+ 4 23 27.5	+26.4	Bess. Albany A.G. Catal. 467
24	1 36 28.89	+3.64	+ 4 8 30.5	+26.4	" " " " 480
25	1 36 44.98	+3.66	+ 3 53 57.8	+26.4	" " " " 483
26	1 34 24.10	+3.68	+ 3 51 49.7	+26.5	" " " " 465
27	1 16 4.65	+3.98	− 0 41 41.5	+27.0	Göttingen 278
28	1 14 26.12	+4.00	− 1 3 36.8	+26.9	Gould. Arg. Gen. Catal. 1241 (F.42 *Ceti*)
29	1 9 27.39	+4.01	− 1 32 8.5	+26.8	Gould, Arg. Gen. Catal. 1156 (F.38 *Ceti*)
30	2 57 11.53	{ +4.06 { +4.10	+ 8 3 34.9	+25.5	Glasgow 703. Yarnall 1342
31	2 42 20.90	+4.29	+ 6 43 33.2	+25.8	Bonn Obsns. VI, 424
32	2 36 54.18	+4.29	+ 6 31 49.7	+25.9	Weisse's Bessel 584
33	2 36 32.96	+4.29	+ 6 25 51.6	+25.8	Weisse's Bessel 577
34	2 30 19.42	+4.42	+ 6 23 7.8	+24.5	Greenwich 80, 386, etc.
35	4 56 22.21	+4.81	+25 37 37.8	+15.0	A.N. 100. p. 247 (Königsberg)
36	4 58 17.17	+4.83	+25 40 17.6	+14.8	Bonn Obsns. VI, 774
37	4 53 9.88	+4.91	+25 46 42.4	+15.8	Weisse's Bessel 1144
38	4 53 8.27	+4.99	+25 38 46.8	+15.9	Weisse's Bessel 1142
39	4 30 59.00	+5.25	+25 30 52.5	+18.7	Yarnall 2013
40	4 32 58.90	+5.28	+25 0 34.2	+18.5	Becker, Berlin A.G. Catal. 1481
41	4 25 58.59	+5.31	+24 57 38.6	+19.6	Becker, Berlin A.G. Catal. 1455
42	4 26 16.49	+5.31	+24 53 49.6	+19.6	Bonn Obsns. VI, 664

Star 28. adopted p.m. —0s.0010, +0″.002. Star 29, adopted p.m. —0s.0063, +0″.220. Star 34, adopted p.m. +0s.1245, —1″.456.

OBSERVATIONS OF (181) *EUCHARIS* AND (288) *GLAUKE*,

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY JOHN H. OGBURN.

1895 Albany M.T.		*	No. Comp.	Planet — * Δα	Planet — * Δδ	Planet's apparent α	Planet's apparent δ	log pΔ for α	log pΔ for δ
				(181) *Eucharis.*					
	h m s			m s	′ ″	h m s	° ′ ″		
April 11	8 18 46	1	7	+3 5.80	−1 15.5	13 3 55.32	+15 22 42.7	n9.546	0.669
18	12 20 4	2	8	+3 28.61	−4 40.6	12 59 4.64	15 58 57.0	9.128	0.604
19	9 14 7	2	8	+2 55.00	−1 7.6	12 58 31.03	16 2 30.1	n9.330	0.618
21	8 28 44	2	9	+1 41.19	+6 19.5	12 57 17.21	16 9 57.5	n9.440	0.632
28	8 40 39	3	7	+2 26.24	+6 35.0	12 53 16.84	+16 29 9.8	n9.304	0.605
				(288) *Glauke.*					
April 21	10 8 47	4	8	+1 9.79	+4 58.1	14 55 57.11	− 8 38 22.3	n9.467	0.824
23	9 31 33	5	9	+0 28.06	+4 58.5	14 54 27.98	− 8 30 15.8	n9.520	0.815
May 1	9 14 13	6	8	−0 49.22	−4 13.4	14 48 5.54	− 8 2 8.6	n9.482	0.817

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	13 0 47.12	+2.40	+15 24 13.1	−15.2	Prof. Boss, 2 observations
2	12 55 33.57	+2.16 +2.15	+16 3 51.6	−14.0 −13.6	Prof. Boss, 2 observations
3	12 50 18.13	+2.14	+16 22 47.4	−12.6	Prof. Boss, 1 observation
4	11 54 15.01	+2.31	− 8 13 2.7	−17.7	A.G. Vienna
5	11 53 57.58	+2.34	− 8 35 26.6	−17.7	A.G. Vienna
6	11 18 52.31	+2.45	− 7 57 36.7	−18.5	Stone, A.G. Vienna

OBSERVATIONS OF THE ALGOL-TYPE STAR 6442 *Z HERCULIS*,

BY PAUL S. YENDELL.

During the season of 1895, I have observed this star on twenty-three nights, the date of the first observations being 1895 April 21, and that of the last October 26. From the end of May to the beginning of August, observations were badly interfered with by unfavorable weather.

From these observations are deduced five principal and eight secondary minima. The odd or secondary minima were found difficult of observation, from the small range of the variation and the indefiniteness of the phase. The even or principal minima, however, were as a rule more easy of observation, and the minima well-defined. No indication of the double minimum suspected by Lindemann is afforded by these observations.

The observed minima are given in the subjoined table, the comparisons being with the elements of Hartwig. The residuals in the fifth column are those resulting from the computed times as given; the sixth column contains the values of the cubical term given further on; the seventh column gives the residuals which result from the application of this term, and the last column the observed magnitude at minimum.

E	Observed Time	Light Eq	Comp. Time	O—C	Cub. Term	O—C′	Mag.
	PRINCIPAL MINIMA.						
	d h m	m	h m	m	m	m	M
160	1895 July 30 12 49	+5.2	14 22.3	− 88.1	− 88.3	+ 0.2	7.9
178	Sept. 4 11 12	+1.8	12 48.5	− 94.7	−121.5	+26.8	8.0
180	8 10 28	+1.4	12 38.0	−128.6	−125.7	− 2.9	7.9
186	20 9 50	0.0	12 6.6	−136.6	−138.7	+ 2.1	7.9
188	24 9 27	−0.4	11 56.2	−149.6	−143.2	− 6.4	8.0
	SECONDARY MINIMA.						
101	April 23 14 33	+3.9	14 36.2	+ 0.7	. . .	. . .	7.9
137	June 14 13 42	+6 7	12 21.1	+ 87.6	. . .	. . .	7.8
159	July 28 10 48	+5.2	10 26.2	+ 27.0	. . .	. . .	7.8
163	Aug. 5 11 15:	+4.2	10 5.2	+ 74.0	. . .	. . .	7.7
173	25 9 53	+3.1	9 12.9	+ 43.2	. . .	. . .	7.7
177	Sept. 2 9 12	+1.5	8 51.5	+ 22.0	. . .	. . .	7.7
181	10 8 49	+1.2	8 30.6	+ 19.6	. . .	. . .	7.7
187	22 8 44	−0.2	7 49.2	+ 54 6	. . .	. . .	7.7

The negative sign of the residuals in the table of principal minima seems to indicate that the mean period since the discovery of the star's variation has been shorter than that assigned by Chandler and Hartwig. This indication is confirmed by the progression shown both in these and to a less distinct degree by those from the secondary minima.

Assembling the observations published by Hartwig, Lindemann and Plassmann (*Astronomische Nachrichten*, Vol. 136, pp. 221, 329, 333, and Vol. 137, p. 11), and by Dunér (*Astrophysical Journal*, May, 1895), I find a decrease of period of substantially the same value for both principal and secondary series, and also that all the observations of principal minima, with the exception of Lindemann's are fairly accounted for by the period of Chandler and Hartwig, with the addition of a term depending on the cube of the epoch ($-0^{d}.0012\,E^3$). The values of this term, and the residuals from my observations of principal minima resulting from its use are given in columns six and seven of the table above.

A consideration of all the minima assembled, back as far as the first Potsdam observations in 1888, seems to me to afford strong indication of the existence of a periodical change in the period of variation, extending over perhaps five or six hundred epochs, though sufficient data have not yet accumulated for a determination of its extent or duration.

It also appears certain that the value given in HARTWIG's ephemeris for the interval from the principal to the secondary minimum is too short by about $2^h\ 10^m$, being $4^h\ 7^m$ less than the half of the period elapsing between two successive principal minima, while the actual mean value shown by my observations is only $1^h\ 27^m$ less than the half-period, approaching much more nearly to the value assigned by DUNÉR.

Dorchester, Mass., 1895 *December* 15.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY PROF. MARY W. WHITNEY AND CAROLINE E. FURNESS.

1895 Greenwich M.T.		*	No. Comp.	Planet — * $\Delta\alpha$	$\Delta\delta$	Planet's apparent α	δ	log $p\Delta$ for α	for δ	Obs.
(306) *Unitas.*										
	h m s			m s	′ ″	h m s	° ′ ″			
Apr. 19	15 23 39	1	12	+0 23.05	− 1 4.4	13 27 50.62	+ 2 36 49.2	*n*9.110	0.745	F
23	16 49 58	2	9	−1 46.22	+ 3 58.8	13 24 13.02	+ 3 2 1.9	8.864	0.741	F
24	15 35 21	2	8	−2 34.69	+ 9 20.9	13 23 24.55	+ 3 7 24.1	*n*8.790	0.740	F
25	15 3 53	3	8	−0 53.06	+ 2 34.9	13 22 33.15	+ 3 12 48.6	9.049	0.739	F
May 1	15 49 28	4	7	−3 49.25	+ 0 45.0	13 17 38.22	+ 3 41 37.6	8.476	0.734	F
2	15 32 53	5	10	+1 56.24	− 4 28.9	13 16 53.49	+ 3 45 36.8	7.810	0.733	F
3	14 37 10	5	8	+1 13.02	− 0 56.4	13 16 10.27	+ 3 49 9.4	8.960	0.733	W
9	14 33 31	6	3	−0 54.43	− 3 44.6	13 12 9.31	+ 4 6 45.7	*n*8.658	0.730	F
	15 10 35	6	7	−0 55.46	− 3 39.2	13 12 8.28	+ 4 6 51.1	8.418	0.730	W
10	15 13 58	6	9	−1 30.72	− 1 36.8	13 11 33.02	+ 4 8 53.6	8.617	0.729	F
11	14 43 29	7	6	+0 40.45	+ 4 50.0	13 10 59.88	+ 4 10 43.9	*n*7.946	0.729	F
	14 57 53	7	8	+0 40.14	+ 4 49.2	13 10 59.57	+ 4 10 43.1	8.280	0.729	W
13	14 49 46	7	13	−0 23.42	+ 7 44.4	13 9 56.01	+ 4 13 38.4	8.313	0.728	F
15	14 43 20	7	8	−1 38.58	+ 8 53.5	13 8 40.85	+ 4 14 47.6	8.411	0.728	F
(349) *Dembowska.*										
May 15	17 18 19	8	10	+1 35.41	− 8 34.5	15 30 27.31	−23 57 1.5	8.754	0.904	F
16	15 35 1	8	11	+0 43.95	− 7 51.3	15 29 35.85	−23 56 18.3	*n*9.172	0.896	W
23	15 53 50	9	9	−0 34.17	− 6 28.9	15 23 10.52	−23 47 37.0	*n*8.599	0.904	W
24	16 58 16	9	5	−1 30.40	− 5 5.7	15 22 14.30	−23 46 13.9	9.023	0.901	W
29	14 56 47	9	6	−5 47.39	+ 2 15.6	15 17 57.37	−23 38 52.9	*n*8.994	0.901	W
June 1	16 16 46	10	4	+4 43.54	+ 3 32.2	15 15 25.50	−23 34 5.7	8.994	0.901	W
(225) *Henrietta.*										
June 17	14 50 53	11	7	−1 14.14	+ 9 34.8	15 16 14.81	+ 2 43 47.1	8.655	0.743	W
23	14 36 50	12	4	−2 40.30	+ 2 46.5	15 11 19.21	+ 2 12 26.2	8.862	0.748	W

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	13 27 25.24	+2.33	+ 2 38 10.3	−16.7	Boss, A.G. Albany 4746
2	13 25 56.91	+2.33	+ 2 58 19.4	−16.3	Boss, A.G. Albany 4738
3	13 23 23.88	+2.33	+ 3 10 29.8	−16.1	Micr. comp. with Alb. 4708 and Cincin. 1177
4	13 21 25.10	+2.37	+ 3 41 8.4	−15.8	Boss, A.G. Albany 4720
5	13 14 54.89	+2.36	+ 3 50 21.2	−15.5	Boss, A.G. Albany 4697
6	13 13 1.40	+2.34	+ 4 10 45.1	−14.8	Boss, A.G. Albany 4680
7	13 10 17.09	+2.34	+ 4 6 8.5	−14.6 −14.4	Boss, A.G. Albany 4673
8	15 28 49.11	+2.79	−23 48 9.9	−17.1	Argent. G.C. 21101
9	15 23 41.88	+2.81 +2.88	−23 40 50.6	−17.5 −17.9	Bonn VI
10	15 10 39.13	+2.83	−23 37 19.3	−18.6	Argent. G.C. 20710
11	15 17 26.25	+2.70	+ 2 34 25.5	−13.2	Boss, A.G. Albany 5193
12	15 13 56.81	+2.70	+ 2 9 52.5	−12.8	Boss, A.G. Albany 5186

OBSERVATIONS OF FAYE'S COMET,

MADE WITH THE 26-INCH TELESCOPE OF THE U.S. NAVAL OBSERVATORY,

By Prof. E. FRISBY, Prof. S. J. BROWN, Assistant Astronomer GEO. A. HILL, and Mr. GEO. ANDERSON.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1895–96 Greenwich M.T.	*	No. Comp.	☌ — * $\Delta\alpha$	☌ — * $\Delta\delta$	☌'s apparent α	☌'s apparent δ	log pΔ for α	log pΔ for δ	Obs.
h m s			m s	′ ″	h m s	° ′ ″			
Nov. 18 12 33 11.3	1	10 , 2	−2 37.56	−3 55.8	21 40 57.05	−5 57 6.3	9.2867	0.7817	F
19 12 35 11.1	1	18 , 3	−1 17.56	−3 51.9	21 42 17.30	−5 57 5.4	9.2769	0.7881	B A
21 11 47 57.7	1a	0 , 3	. . .	−1 55.2	. . .	−5 56 37.8	. . .	0.6927	B
12 13 39.7	1a	5 , 0	−0 2.43	. . .	21 45 2.21	. . .	9.2157	. . .	B
Dec. 16 12 16 45.7	2	18 , 4	−0 21.17	−6 26.4	22 26 6.66	−4 52 24.9	9.4358	0.7766	B H
Jan. 11 12 23 27.7	3a	8 , 1	+0 11.78	−5 21.6	23 18 51.85	−2 1 4.6	9.5472	0.7543	B
14 12 33 9.7	4a	8 , 4	+0 4.42	+0 21.4	23 25 28.11	−1 35 31.3	9.5700	0.7510	B
15 11 51 27.7	5	8 , 4	+0 11.06	−2 2.3	23 27 37.88	−1 27 6.1	9.5100	0.7519	B

The comet was very distinct Jan. 15. Under a power of 400 it showed decided condensation at the center of its faint nebulous mass 30″ diameter. — S.B.

Mean Places for 1895.0 and 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 43 31.90	+3.07	−5 53 24.5	+11.0	$\frac{1}{3}$(Yarnall 9806, Radcliffe$_3$ + Gould)
1a	21 45 1.59	+3.05	−5 51 56.6	+14.0	$10^{M}.5$. From 1, $\Delta\alpha$, $+1^{m}\ 29^{s}.69$; $\Delta\delta$, $-1'\ 32''.1$
2	22 26 24.85	+2.98	−4 46 16.3	+17.8	Munich (2) 12542
3	23 18 25.37	−0.09	−1 53 23.0	− 1.3	Weisse's Bessel XXIII. 325
3a	23 18 40.16	−0.09	−1 55 41.7	− 1.3	$10^{M}.5$. From 3, $\Delta\alpha$, $+14^{s}.79$; $\Delta\delta$, $-2'\ 18''.7$
4	23 24 10.25	. . .	−1 36 27.0	. . .	Radcliffe$_3$ 6273
4a	23 25 23.80	−0.08	−1 35 51.6	− 1.1	12^{M}. From 4, $\Delta\alpha$, $+73^{s}.55$; $\Delta\delta$, $+35''.4$
5	23 27 26.88	−0.06	−1 25 2.8	− 1.05	Weisse's Bessel XXIII. 506

A magnifying power of 175 was used throughout. The following corrections have been applied to the comet's α to reduce it to the same epoch as the declination. The corrections are included in $\Delta\alpha$. Nov. 18, for $3^{m}.25$, $\Delta\alpha$ $-0^{s}.18$; Nov. 19, for $4^{m}.01$, $\Delta\alpha$ $+0^{s}.24$; Dec. 16, for $0^{m}.6$, $\Delta\alpha$ $+0^{s}.03$; Jan. 11, for $0^{m}.8$, $\Delta\alpha$ $+0^{s}.06$; Jan. 14, for $0^{m}.3$, $\Delta\alpha$ $-0^{s}.03$; Jan. 15, for $1^{m}.3$ $\Delta\alpha$ $-0^{s}.12$.

ON THE VARIABILITY OF THE STAR* DM. +0°939.

$5^{h}\ 0^{m}\ 14^{s}$, $+1°\ 2'.4$ (1900)

By EDWIN F. SAWYER.

The probable variability of this star, which is numbered 653 in the Potsdam Photometric Catalogue, was strongly suspected 1895 January 29, in the observation of a sequence in connection with my revision of the magnitudes in the Potsdam catalogue, which I had began in the previous November. This star, estimated as $6^{M}.08$ in the above catalogue, although difficult on account of its red color, was estimated so faint as to exclude it from the sequence which took in other stars in its vicinity, and in consequence it was independently compared with the star no. 630 in the same catalogue, and given as $7^{M}.21$, and found to be 5 steps fainter, or about $7^{M}.7$. It was marked "variable?", and especially noted for close watching. On February 14, the star was again observed, and noted as still very faint. On March 23, it was estimated as equal to no. 630, or $7^{M}.2$, and marked as undoubtedly variable. It was, however, thought advisable before making the announcement, as heretofore done where the least doubt remained, to obtain one more observation as soon as the star became favorably situated for observation. This occurred on November 11, when it was estimated to be 3 or 4 steps > no. 614, or about $6^{M}.5$, thus placing its variability beyond doubt. It is now (1896 January 8) fading, and is 3 steps < no. 614, or $7^{M}.2$. It is no. 96 in BIRMINGHAM's catalogue, and is very red, about 8 of CHANDLER's scale.

While preparing an announcement of its variability, I was informed by Dr. CHANDLER that Prof. PICKERING had recently announced its variability from an examination of photographic plates. The above observations, therefore, confirm independently the star's fluctuation in light.

Brighton, 1896 *January* 11.

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* Definitive notation, 1800 W *Orionis*. — Ed.

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Published in Boston, semi-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed February* 14.

THE

ASTRONOMICAL JOURNAL.

No. 367.

VOL. XVI. BOSTON, 1896 FEBRUARY 29. NO. 7

FILAR-MICROMETER MEASURES OF THE FIFTH SATELLITE OF *JUPITER*,

MADE DURING THE OPPOSITION OF 1894 WITH THE 36-INCH REFRACTOR OF THE LICK OBSERVATORY,

By E. E. BARNARD.

On account of the opposition of *Jupiter* in 1894 falling in the bad season for observation at Mt. Hamilton — and that season being an especially bad one — a few measures only of the Fifth Satellite were obtained. In but one instance was it possible to cover the elongation-time.

In all the measures the satellite was very difficult, and when the wind was blowing, as it frequently was, the measures were made with the utmost difficulty.

I have collected all my measures made at this opposition, and give them here in full. They were made, as at previous observations of this satellite, by obscuring the planet with a piece of smoked mica covering half the field. For the distances the threads were carefully placed perpendicular to the belts, by first determining the parallel of the belts. For the polar measures on November 18 the wires were placed perfectly parallel to the belts.

Following is a collection of the position-angles of *Jupiter's* belts as determined from these settings.

	h m	°	
1894 Sept. 3	17 20	94.6	(1 obs.)
18	16 20	92.6	(1 obs.)
Sept. 23	15 45	93.5	(1 obs.)
30	17 0	93.2	(1 obs.)
Oct. 8	13 55	94.4	(2 obs.)
29	13 30	95.4	(1 obs.)
Nov. 4	12 30	94.4	(1 obs.)
11	11 30	93.9	(1 obs.)
12	11 0	93.2	(1 obs.)
18	10 50	93.5	(2 obs.)
Dec. 23	13 12	91.2	(3 obs.)
1895 Jan. 6	12 15	90.3	(3 obs.)
Feb. 4	7 30	89.7	(3 obs.)
17	9 0	89.2	(3 obs.)
24	9 0	88.6	(4 obs.)
25	6 30	89.0	(4 obs.)
Mar. 31	9 0	91.0	(4 obs.)
Apr. 21	8 20	90.9	(1 obs.)
22	6 35	92.3	(1 obs.)

By adding 90° to these position-angles that of the threads at the settings for the distances can be obtained. I have given in the last column the number of independent settings from which the position-angles were determined.

As usual, throughout this paper the observation-times are 8ʰ 0ᵐ slow of Greenwich, being "Standard Pacific Time."

1894 *October* 8.

Satellite preceding.

Standard Pac. Time	Circle	Δ from prec. limb	Δ from center
h m s	r	″	″
13 59 12	52.621	25.16	45.47
14 5 9	53.049	29.40	49.71
14 8 37	52.951	28.43.	48.74
14 12 14	52.921	28.13	48.44
14 14 17	53.003	28.94	49.25
14 18 12	53.269	31.58	51.89
14 23 7	53.215	31.04	51.35
14 25 37	53.209	30.98	51.29
14 27 52	53.200	30.89	51.20

Coincidence of threads = 50ʳ.080.

1894 *October* 29.

Satellite preceding.

Standard Pac. Time	Circle	Δ from prec. limb	Δ from center
h m s	r	″	″
13 36 42	47.071	29.83	51.58
13 39 32	46.987	30.67	52.42
13 41 27	47.172	28.83	50.58
13 42 57	47.188	28.68	50.43
13 44 47	47.322	27.35	49.10
13 46 57	47.253	28.03	49.78
13 48 17	47.296	27.61	49.36
13 51 12	47.357	27.00	48.75
13 55 19	47.450	26.07	47.82
13 57 17	47.678	23.82	45.57

Coincidence of threads = 50ʳ.084.

Satellite very faint, and not seen steadily.

1894 *November* 4.

Satellite preceding.

Standard Pac. Time	Circle	Δ from prec. limb	Δ from center
h m s	r	″	″
12 35 31	46.825	33.09	55.25
12 37 1	46.968	31.68	53.84
12 39 28	46.958	31.77	53.93
12 41 46	46.761	33.73	55.89
12 43 6	47.095	30.42	52.58
12 45 10	46.808	33.26	55.42
12 46 33	46.882	32.53	54.69
12 49 46	46.938	31.97	54.13
12 50 56	46.863	32.72	54.88
12 52 46	46.883	32.52	54.68
12 54 36	47.035	31.01	53.17
12 46 41	47.063	30.74	52.90
12 58 36	46.928	32.07	54.23
13 0 11	47.089	30.48	52.64
13 13 46	47.284	28.55	50.71
13 18 38	47.423	27.17	49.33
13 20 46	47.520	26.21	48.37
13 22 1	47.569	25.73	47.89
13 23 31	47.555	25.86	48.02
13 25 31	47.611	25.31	47.47
13 32 21	47.758	23.85	46.00
13 35 1	47.910	22.35	44.51
13 36 16	47.955	21.91	44.06
13 38 11	47.882	22.63	44.79

Coincidence of threads = 50ʳ.165.

1894 *November* 11.

Satellite preceding.

Standard Pac. Time h m s	Circle r	Δ from prec. limb ″	Δ from center ″
11 40 47	92.262	34.58	57.14
11 41 45	92.368	33.53	56.09
11 42 38	92.301	34.19	56.97
11 45 6	92.326	33.95	56.51
11 46 12	92.280	34.40	56.96
11 47 20	92.329	33.91	56.47
11 49 27	92.294	34.26	56.82
11 57 45	92.326	33.95	56.51
11 59 40	92.307	34.13	56.69
12 1 21	92.366	33.55	56.11
12 3 10	92.390	33.31	55.87
12 4 22	92.309	34.11	56.67
12 4 55	92.309	34.11	56.67
12 7 40	92.380	33.41	55.97
12 8 45	92.358	33.63	55.19
12 10 53	92.346	33.75	56.53
12 12 35	92.412	33.09	55.87
12 14 32	92.490	32.32	54.88
12 16 27	92.469	32.53	55.09
12 18 22	92.488	32.34	54.90
12 19 45	92.532	31.90	54.46
12 21 35	92.534	31.88	54.44
12 23 1	92.601	31.22	53.78
12 33 36	92.747	29.78	52.34
12 39 53	92.903	28.23	50.79

Coincidence of threads = 95r.754.

1894 *November* 12.

Satellite preceding.

Standard Pac. Time h m s	Circle r	Δ from prec. limb ″	Δ from center ″
12 35 10	92.935	27.91	50.59
12 38 28	92.884	28.42	51.10
12 40 52	93.062	26.66	49.34
12 44 31	93.153	25.76	48.41
12 46 20	93.253	24.76	47.44

Coincidence of threads = 95r.754.

1894 *November* 18.

Satellite preceding.

Standard Pac. Time h m s	Circle r	Δfr.N.limb ″	Jov.lat. ″
11 8 12	97.863	21.35	+0.41
11 10 0	97.833	21.05	+0.71
11 10 57	97.940	22.11	−0.35
11 12 57	97.800	20.73	+1.03

1894 *November* 18.—Contin.

Standard Pac. Time h m s	Circle r	Δfr.S.limb ″	Jov.lat. ″
11 14 17	93.530	21.56	−0.20
11 15 12	93.549	21.37	−0.39
11 16 22	93.467	22.18	+0.42
11 17 20	93.508	21.77	+0.01
11 18 17	93.568	21.18	−0.58
11 20 7	93.451	22.34	+0.58
		Δfr.N.limb	
11 24 17	97.819	20.91	+0.85
11 26 4	97.738	20.11	+1.65
11 27 12	97.745	20.18	+1.58
11 28 22	97.803	20.76	+1.00
11 29 32	97.842	21.15	+0.61
11 30 37	97.812	20.84	+0.92
11 32 7	97.814	20.86	+0.90
11 33 32	97.882	21.54	+0.22
11 34 27	97.802	20.75	+1.01
11 35 22	97.823	20.95	+0.84
		Δfr.S.limb	
11 39 17	93.513	21.72	−0.04
11 41 20	93.407	22.77	+1.01
11 42 42	93.501	21.84	+0.08
11 43 47	93.464	22.21	+0.45

Coincidence of threads = 95r.707.

The last column gives the distance of the satellite north or south from the apparent center of the disc, or its apparent Jovian latitude.

1894 *November* 19.

Satellite preceding.

Standard Pac. Time h m s	Circle r	fr.pr.limb ″	fr.center ″
11 35 8	92.278	33.89	56.94
11 36 24	92.435	32.34	55.39
11 37 41	92.410	32.59	55.64
11 39 19	92.474	31.95	55.00
11 41 29	92.530	31.40	54.45
11 43 27	92.559	31.11	54.16
11 44 54	92.503	31.67	54.72
11 45 49	92.698	29.74	52.79
11 47 11	92.600	30.71	53.76

1894 *November* 19.—Contin.

Standard Pac. Time h m s	Circle r	Δfr.fol.limb ″	Δ from center ″
11 53 29	88.112	75.15	51.94
11 55 11	88.123	75.04	51.83
11 56 34	88.123	75.04	51.83
11 58 41	88.306	73.23	50.02
12 0 9	88.303	73.26	50.04
12 1 56	88.418	72.12	48.91
12 3 24	88.388	72.41	49.20
12 5 14	88.423	72.07	48.86
12 7 14	88.535	70.96	47.75
12 10 29	88.528	71.03	47.82
12 11 29	88.626	70.06	46.85

Coincidence of threads = 95r.701.

1894 *December* 3.

Satellite following.

Standard Pac. Time h m s	Circle r	Δfr.fol.limb ″	Δ from center ″
15 9 55	92.509	33.09	56.88
15 11 15	92.464	33.54	57.33
15 12 57	92.512	33.06	56.85
15 14 7	92.441	33.77	57.56
15 15 49	92.402	34.15	57.94
15 18 24	92.443	33.75	57.54
15 22 35	92.338	34.79	58.58
15 24 25	92.426	33.91	57.70
15 26 0	92.302	35.14	58.93
15 27 57	92.210	36.05	59.84
15 33 2	92.273	35.43	59.22
15 34 27	92.243	35.73	59.52
15 37 30	92.252	35.64	59.43
15 40 30	92.276	35.40	59.19
15 42 0	92.215	36.00	59.79
15 44 5	92.238	35.78	59.57
15 46 15	92.130	36.84	60.63
15 48 40	92.250	35.66	59.45
15 52 10	92.245	35.71	59.50
15 56 5	92.384	34.33	58.12
15 58 2	92.330	34.87	58.66
15 59 45	92.395	34.22	58.01
16 2 30	92.340	34.77	58.56
16 4 13	92.355	34.61	58.41
16 17 0	92.553	32.66	56.45
16 18 55	92.512	33.06	56.85
16 23 25	92.655	31.65	55.44

Coincidence of threads = 95r.851.

Plotting the measures on each side of elongation, the elongation-distance is found to be 59″.50, or, at Δ 5.20 = 48″.17, and the elongation-time = 15h 44m.

The elongation-time, computed from the measures on each side of elongation, = 15h 43m.2. Assuming the mean of these two values, from the graphical and computed results, we have

East elongation, 1894 December 3, 15h 43m.6 St. Pac. Time,
or December 3, 23h 43m.6 Greenw. M.T.

This was the only observed elongation possible during the opposition of 1894.

Marth (*A.N.* 3253) gives an ephemeris of this satellite for the opposition of 1894. For December 3 his ephemeris gives east elongation at 23h 42m.4 Gr. M.T.

My observation would show that the satellite is a little over one minute of time behind his ephemeris, which is based on a period of 11h 57m 22s.60.

As only one elongation was observed in 1894, this correction may be somewhat uncertain. It would seem, however, that the above period will represent the motion of the satellite with sufficient closeness to find it for several years to come.

Mr. Marth also gives the apparent elongation-distance for December 3 as 59″.41, which is in close accord with my measures (59″.50).

The observations are corrected for phase.

OBSERVED MINIMA OF 7488 *Y CYGNI*,

By PAUL S. YENDELL.

During the season of 1895 I observed five minima of this star, as follows:

1895 July 30, thirteen observations, from 9h 47m to 14h 9m Local M.T.

Time of minimum by single curve, 12h 34m, wt. 3.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
8.0	11 28	13 9	12 18.5
8.2	11 58	13 49	12 53.5
	Mean,		12 36.0

Least observed light, 8M.30.

1895 September 1, eighteen observations, from 8h 45m to 13h 43m.

Time of minimum by single curve, 11h 46m, wt. 4. Bright moonlight.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
7.8	10 37	13 40	12 8.5
8.0	11 2	13 20	12 11.0
8.2	11 24	12 30	11 57.0
8.4	11 38	11 50	11 44.0
	Mean,		12 0.1

Least observed light, 8M.40.

This minimum was an exceptionally well-determined one, the bright moonlight proving an advantage instead of an impediment, by reducing the contrast between the star and the background, and consequently the glare.

1895 November 30, ten observations, from 7h 19m to 9h 26m.

Time of minimum by single curve, 8h 25m, wt. 3. Bright moonlight.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
8.2	7 39	9 9	8 24.0
8.4	8 10	8 42	8 26.0
	Mean,		8 25.0

Least observed light, 8M.46.

1895 December 3, eight observations, from 7h 18m to 9h 26m.

Time of minimum by single curve, 8h 22m, wt. 2. Bright moonlight.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
8.4	8 0	8 46	8 23

Least observed light, 8M.48.

1895 December 6, six observations, from 7h 15m to 9h 10m.

Time of minimum by single curve, 8h 30m, wt. 1.

Time of minimum by equal brightness:

	Before	After	Mean
M	h m	h m	h m
8.4	8 19	8 43	8 31

Least observed light, 8M.45.

I have given no mean curve reductions, as I have no satisfactory curve.

Assembling the times deduced from the single curves, and reducing them, for the sake of convenience in comparison, to Greenwich Mean Time, we find the comparisons with Hartwig's ephemeris are as follows:

E	Observed Minima Gr. M.T.	wt.	Light Eqn.	Comp. Time Gr. M.T.	O—C
	1895 d h m		m	h m	m
2106	July 30 17 18.5	3	+4.9	18 1.2	—37.8
2128	Sept. 1 16 30.5	4	+5.1	17 5.3	—29.7
2188	Nov. 30 13 9.5	3	—1.1	14 33.9	—85.5
2190	Dec. 3 13 6.5	2	—1.5	14 27.8	—82.8
2192	6 13 14.5	1	—1.6	14 21.9	—69.0

The persistence of the negative sign in the above residuals, and the plainly indicated increase in their value, appear to show that the intervals between the odd and even minima have ceased to increase, and are now diminishing; this would seem to imply that this interval is periodically variable within limits as yet undetermined, the variation being possibly due to a revolution of the line of apsides.

It is hoped that observations of the odd minima during the time covered by the above observations will be forthcoming, so as to confirm or contradict the inference drawn from these of the even series.

Dorchester, Mass., 1896 *January* 13.

OBSERVATIONS OF VARIABLE STARS, — No. 2,

By WM. E. SPERRA.

The following list of observed maxima and minima is like the preceding one (*A.J.* 350) arranged in two parts, embracing observations of long and short-period stars respectively. The time included is from 1895 April to 1895 November, and they were made, except where otherwise stated, with a 3-inch refractor, by the Argelander method. The magnitudes, unless otherwise stated, are on the historic scale. The time, when expressed in the decimal of a day, is Greenwich Mean Time.

103. *T Andromedae.*

A maximum at 7M.8 for 1895 September 7.5 is indicated from twenty-nine observations, extending from 1895 July 30 to 1895 October 23.

2815. *U Geminorum.*

A maximum is indicated for about 1895 October 28.0, from the four observations below. Magnitude on BAXENDELL's scale, $9^{M}.2$.

	M		M
1895 Oct. 27.0	9.5	Oct. 30.0	9.5
28.0	9.1	Nov. 1.0	9.7

3825. *R Ursae Majoris.*

Twenty-nine observations, from 1895 March 24, when the star was below 10^{M}, to 1895 July 30, when the star had fallen to some below $8^{M}.5$, indicate the date of maximum very definitely for 1895 June 2, at $6^{M}.8$.

4511. *T Ursae Majoris.*

This star was observed twenty-five times, from 1895 March 16 to 1895 June 22. It was about $9^{M}.8$ at first observation, and at the last one about $9^{M}.3$. The date of maximum is indicated quite definitely for 1895 April 30, at $8^{M}.0$. Both rise and fall were regular.

4521. *R Virginis.*

A maximum of $6^{M}.9$ is very definitely indicated, from nineteen observations, for 1895 May 28.5. Observations extend from 1895 April 17, when star was of $8^{M}.7$, to 1895 June 27, when it had again reached that light. The rise was slower than the fall; however, both were regular.

4847. *S Virginis.*

Twenty-five observations, from 1895 April 17 to 1895 July 16, yield the date of maximum as 1895 May 21.5, at $6^{M}.4$. At first observation the star was at $8^{M}.4$, and at last about $7^{M}.7$.

5194. *V Bootis.*

Continuing to follow this star from the maximum referred to in my former paper (*A.J.* 350), it was observed forty-eight times, from 1895 April 10 to 1895 October 9, yielding the date of minimum for 1895 July 29, at $8^{M}.9$. Commencing soon after the last observation given in my former paper, the remainder of the decrease was marked by considerable fluctuation and irregularities, as indicated by the observations. Soon after the minimum was passed these fluctuations ceased, and the observations lie close to curve again.

5237. *R Bootis.*

Nineteen observations, from 1895 August 7 to 1895 October 13, yield the date of maximum as 1895 September 22.0, at $7^{M}.3$. At first and last observations the star was at $9^{M}.2$ and $7^{M}.8$ respectively.

7085. *RT Cygni.*

Continuing to follow this star, thirty-five observations, from 1895 May 20 to 1895 August 20, indicate the date of maximum very definitely for 1895 July 15.0, at $7^{M}.0$. The curve for this maximum presents an entirely different form from that of 1894 Dec. 17, described in my paper already alluded to. Starting at below $9^{M}.5$ at first date, it rose quite rapidly to $8^{M}.0$ by June 10, then more slowly until about June 25, when $7^{M}.5$ was reached; then more rapidly again until at maximum light it stood for about ten days, falling then more rapidly than it rose to $7^{M}.8$ by Aug. 8; increasing its rate of decrease it reached $9^{M}.5$ Aug. 20.

7118. *X Aquilae.*

Ten observations from June 17 to 1895 July 24, indicate the maximum phase for 1895 July 6, at approximately $9^{M}.0$.

SHORT-PERIOD VARIABLES.

4805. *W Virginis.*

Twenty-eight observations, from 1895 May 12 to 1895 June 24, yield as follows:

		M
Max.	1895 May 17.0	8.7
Max.	June 1.7	8.9
Max.	19.3	8.6

6636. *U Sagittarii.*

Twenty-six observations, from 1895 May 20 to 1895 August 23, yield by mean light-curve (published by Mr. YENDELL in *Popular Astronomy*, no. 18) as follows:

MAXIMA	Obs.	Wt.	MINIMA	Obs.	Wt.
1895 May 29.20	2	1	1895 June 22.82	2	1
June 18.48	2	1	Aug. 8.01	2	1
26.05	2	1	16.06	2	1
July 17.28	2	1	22.84	3	1
Aug. 11.60	3	1			

6758. *β Lyrae.*

This star was observed sixty times by naked eye, from 1895 July 9 to 1895 November 21, and the yield by mean curve (SCHONFELD's as published in no. 15 of the above-named Journal by Mr. YENDELL) of principal minima is only three, as follows:

	Obs.	Wt.
1895 July 25.94	2	1
Aug. 7.78	2	1
Sept. 2.96	3	1

7124. *η Aquilae.*

Twenty-six naked-eye observations of this star were obtained between 1895 Aug. 13, and 1895 Nov. 15. No mean light-curve of this star being at hand, one for the maximum phase was constructed from my own observations by using the period of the star. The resulting maxima by this curve are as follows:

	Obs.	Wt.		Obs.	Wt.
1895 Aug. 13.99	2	1	1895 Sept. 13.00	2	1
22.19	3	1	19.91	4	1
29.21	2	1	Oct. 18.52	3	1

This last maximum was also reduced by the graphic method from five observations, which gave the time as Oct. 18.56.

7437. *X Cygni.*

Fifty-three observations of this star, from 1895 May 16 to 1895 Aug. 21, yield results as follows:

			M
1895 June	1.83	Min.	6.7
	7.23	Max.	6.3
	18.13	Min.	6.6
	24.48	Max.	6.3
July	4.38	Min.	6.6
1895 July	10.13	Max.	6.3
	18.93	Min.	6.7
	26.38	Max.	6.3
Aug.	7.88	Min.	6.7
	12.83	Max.	6.2

Randolph, Ohio, 1896 *January* 28.

OBSERVATIONS OF COMET *c* 1895 (*PERRINE*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

1895 Mt. Hamilton M.T.	*	No. Comp.	☄ − * $\Delta\alpha$	☄ − * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			BY R. G. AITKEN.					
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 20 16 58 40.0	6	13 , 9	+2 9.44	− 3 23.9	13 53 32.23	− 0 25 59.4	*n*9.653	0.729
*21 17 23 39.0	7	10 , 5	+6 46.48	− 2 31.3	13 56 6.99	− 1 1 58.5	*n*9.634	0.732
17 23 39.0	8	10 , 5	+1 30.03	+ 4 2.2	13 56 7.57	− 1 1 58.4	*n*9.634	0.732
22 17 35 43.5	9	10 , 7	+1 39.92	+ 2 1.6	13 58 48.69	− 1 39 31.5	*n*9.624	0.735
			BY C. D. PERRINE.					
Nov. 23 17 50 19	10	8 , 5	−3 55.24	− 8 15.8	14 1 39.58	− 2 19 16.7	*n*9.607	0.739
24 16 58 55	11	24 , 8	+1 34.57	+ 2 57.3	14 4 32.36	− 2 59 20.5	*n*9.651	0 736
25 17 8 53	12	34 , 10	+0 37.71	+ 2 21.9	14 7 44.75	− 3 43 44.4	*n*9.644	0.739
30 18 1 19	13	10 , 4	−2 29.05	− 6 3.6	14 27 45.84	− 8 13 17.9	*n*9.598	0.767
Dec. 1 17 15 14	14	12 , 12	+0 10.07	+ 0 39.1	14 32 39.11	− 9 16 34.0	*n*9.645	0.756
3 17 20 40	15	13 , 4	−0 38.79	− 7 15.9	14 41 17.42	−11 42 30.4	*n*9.648	0.761
4 17 33 53	16	7 , 8	+0 23.12	−12 45.0	14 51 7.16	−13 4 37.9	*n*9.641	0.768
7 17 31 16	17	10 , 6	+1 36.63	+ 0 43.0	15 16 35.28	−17 46 8.1	*n*9.665	0.767
18 9 20	18	8 , 8	+0 32.32	+ 3 52.8	15 16 51.45	−17 48 51.2	*n*9.629	0.791
9 18 13 43	19	11	+1 2.83	. . .	15 39 53.03	. . .	*n*9.650	. .
18 25 56	19	3	. . .	+ 0 30.4	. . .	−21 28 40.8	. .	0.798
10 18 13 44	20	14	+2 8.96	. . .	15 53 45.59	. . .	*n*9.667	. .
18 31 35	20	3	. . .	−10 58.5	. . .	−23 24 34.8	. .	0.797
11 18 28 42	21	2	. . .	− 7 1.5	. . .	−25 19 52.1	. .	0.788
18 34 20	22	2	−5 8.39	. . .	16 9 42.30	. . .	*n*9.665	. .

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
6	13 51 20.86	+1.93	− 0 22 18.4	−17.1	Schjellerup 4981
7	13 49 18.55	+1.96	− 0 59 10.0	−17.2	Radcliffe (3) 3604
8	13 54 35.59	+1.95	− 1 5 13.4	−17.2	½ (Copeland-Börgen 4101 + Münich II. 5126)
9	13 57 6.81	+1.96	− 1 41 15.9	−17.2	Radcliffe (3) 3636
10	14 5 32.86	+1.96	− 2 10 43.7	−17.2	⅓ (2 Schj. 5054 + Münich I, 9917)
11	14 2 55.81	+1.98	− 3 2 0.6	−17.2	½ (Radcliffe (3) 3661 + Schj. 5040)
12	14 7 5.04	+2.00	− 3 45 49.1	−17.2	⅓ (2 Schj. 5059 + Weisse's Bessel XIV, 65)
13	14 30 12.84	+2.05	− 8 6 57.6	−16.7	Cordoba Gen. Catal. 19772
14	14 32 26.96	+2.08	− 9 16 56.4	−16.6	½ (Radcliffe (3) 3784 + Schj. 5190)
15	14 44 54.09	+2.12	−11 34 58.3	−16.2	Radcliffe (3) 3835
16	14 50 41.90	+2.14	−12 51 36.9	−16.0	½ (W. Bessel XIV, 909 + Münich I, 10723)
17	15 14 56.44	+2.21	−17 46 36.0	−15.1	½ (Cordoba Gen. Catal. 20792 + Radcl. (3) 3955)
18	15 16 16.92	+2.21	−17 52 28.9	−15.1	Oeltzen-Argelander 11843
19	15 38 47.95	+2.25	−21 28 57.0	−14.2	" " 12114
20	15 51 34.35	+2.28	−23 13 22.7	−13.6	Cordoba Gen. Catal. 21622
21	16 8 31.62	+2.31	−25 12 37.6	−13.0	" " " 22004
22	16 14 48.37	+2.32	−25 20 27.0	−12.7	" " " 22158

* Seeing very bad, owing to wind and haze.

The zenith-distance was large in the later observations, notably Dec. 9, 10 and 11.

The differences of right-ascension on Dec. 1, 4, 7_2, were measured directly with the micrometer.

ON A SUSPECTED VARIABLE IN *ORION*,

$\alpha = 4^h\ 58^m\ 14^s.9, \qquad \delta = +3^\circ\ 50'.3 \quad (1855),$

By PAUL S. YENDELL.

I have used this star, which is DM. 3°764, 9ᴹ.4, as a comparison-star for 1805 *V Orionis*, in 1893 and 1894. It was compared with *V* on the following dates: 1893 Dec. 10, 17 and 29, and 1894 Feb. 22, and Mar. 1, 3 and 7, and Nov. 9. Its estimated magnitude, from these observations, is 9ᴹ.6.

During the present season, I have looked for *V* on 1895 Nov. 29 and Dec. 6, 16 and 29, and retain a distinct impression, though no note was made of the fact, that on these occasions I did not see 764. On 1896 Jan. 4, I saw *V*, and estimated it as about 11ᴹ, and my note of the observation reads "could not see *a*" (764). On Jan. 11 and 18, and Feb. 1, the field was again observed, and on neither occasion was *a* seen; on the last-mentioned date the sky was unusually clear, the moon absent, and the star's hour-angle less than one hour; *V* was seen, and again estimated as 11ᴹ, but no trace of *a* was perceptible, the limit of vision being estimated as about 12ᴹ.

In view of these observations, the star's variability seems very probable, and the attention of observers who possess optical means adequate to its verification is hereby called to it.

Dorchester, 1896 *February* 5.

OBSERVATIONS OF COMET *d* 1895 (BROOKS),

MADE AT THE LICK OBSERVATORY, WITH THE 12-INCH EQUATORIAL,

By R. G. AITKEN.

1895 Mt. Hamilton M.T.		✱	No. Comp.	☄ — ✱		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Dec. 7	9 38 58	5	10 , 7	−0 57.52	+0 14.5	8 17 46.21	+42 4 40.2	*n*9.798	0.529
	10 26 24	7	6 , 4	−0 17.32	−7 28.2	8 17 24.56	+42 12 48.8	*n*9.779	0.384
8	9 2 32	8	10 , 10	−0 38.70	+5 0.1	8 6 21.03	+45 58 15.3	*n*9.829	0.554
9	9 31 46	9	14 , 5	+0 21.42	+3 34.3	7 53 22.25	+49 44 5.3	*n*9.848	0.332
10	11 0 7	10	6 , 6	+0 59.15	+5 23.7	7 38 40.23	+53 15 48.0	*n*9.778	*n*9.633
11	10 33 33	11	10 , 6	+0 42.67	−0 20.3	7 23 53.11	+56 10 12.8	*n*9.823	*n*9.799
12	11 17 5	13	8 , 6	−1 2.66	−3 7.9	7 7 16.11	+58 50 45.5	*n*9.723	*n*0.328

Mean Places for 1895.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
5	8 18 38.23	+5.50	+42 4 41.4	−15.7	Micrometer-comparison with (6)
6	8 20 55.41	+5.50	+42 3 42.2	−15.7	Deichmüller, Bonn A.G. Catal. 6608
7	8 17 36.24	+5.54	+42 20 32.4	−15.4	" " " 6569
8	8 6 56.61	+6.12	+45 53 28.8	−13.6	" " " 6461
9	7 52 54.19	+6.64	+49 40 48.7	−11.7	" " " 6330
10	7 37 33.94	+7.14	+53 10 34.1	− 9.8	Rogers, Cambridge, Mass., A.G. Catal. 2941
11	7 23 2.79	+7.65	+56 10 40.8	− 7.7	Micrometer-comparison with (12)
12	7 28 11.12	+7.59	+55 59 9.6	− 8.6	Krueger, Helsingfors-Gotha A.G. Catal. 5147
13	7 8 40.60	+8.17	+58 53 58.9	− 5.5	Micrometer-comparison with (14)
14	7 9 32.29	+8.20	+59 6 15.9	− 5.7	Krueger, Helsingfors-Gotha A.G. Catal. 4993

OBSERVATIONS OF COMET *a* 1896,

MADE AT THE LICK OBSERVATORY WITH THE 12-INCH EQUATORIAL,

By C. D. PERRINE.

1896 Mt. Hamilton M.T.		✱	No. Comp.	☄ — ✱		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Feb. 14	17 37 3	1	3	. . .	+9 31.3	. . .	−2 51 0.3	. .	0.713
	17 54 11	1	8	−3 15.27	. . .	19 21 57.95	. . .	*n*9.594	. .
15	16 40 13	2	16 , 6	−1 11.24	+2 1.4	19 29 30.22	−0 0 59.9	*n*9.660	0.728
16	16 37 36	3	11 , 8	−0 17.98	+0 10.7	19 38 33.60	+3 15 48.7	*n*9.664	0.720

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 25 13.35	−0.13	−3 0 19.6	−12.0	½ (Schjellerup 7371 + Cord. Gen. Catal. 26737)
2	19 30 41.62	−0.16	+0 1 13.9	−12.4	½ (Radcliffe (3) 5221 + Cord. Gen. Catal. 26853)
3	19 38 51.79	−0.21	+3 15 50.7	−12.7	Boss, Albany A.G. Catal. 6821

EPHEMERIS OF COMET *c* 1895 (*PERRINE*),

BY C. D. PERRINE.

The following ephemeris is computed from the elements of Professor CAMPBELL, published in the *Astronomical Journal*, no. 361.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1896	App. α	App. δ	log *r*	log Δ	Br.
	h m	° ′			
March 1.5	19 47.0	+ 2 9	0.248	0.359	0.15
5.5	46.8	3 15			
9.5	46.3	4 21	0.280	0.361	
13.5	45.5	5 27			
17.5	44.3	6 34	0.309	0.362	0.11
21.5	42.7	7 42			
25.5	40.7	8 50	0.336	0.360	
29.5	38.3	9 58			
April 2.5	35.4	11 6	0.360	0.358	0.09
6.5	19 32.1	+12 15			
April 10.5	19 28.2	+13 23	0.382	0.355	
14.5	23.9	14 30			
18.5	19.0	15 37	0.403	0.352	0.07
22.5	13.6	16 41			
26.5	7.6	17 43	0.423	0.351	
30.5	19 1.1	18 43			
May 4.5	18 54.3	+19 39	0.441	0.352	0.06

1896 Feb. 5^d 18^h — Correction to the Ephemeris:
in α -5^s , in δ $+2'.9$

As the observations upon which the orbit is based were made November 17, 24 and December 1. before perihelion passage, the corrections to the present ephemeris will not vary rapidly.

Mt. Hamilton, Cal., 1896 *Feb.* 17.

ELEMENTS AND EPHEMERIS OF COMET *a* 1896,

BY A. O. LEUSCHNER AND F. H. SEARES.

The following elements of Comet *a* 1896 were deduced with the assistance of Mr. F. H. SEARES, Fellow in Astronomy, from observations made at Mount Hamilton by Mr. C. D. PERRINE on February 15.1, 16.0 and 17.0 Gr. M.T. The observations were kindly telegraphed to the Students' Observatory by Prof. E. S. HOLDEN.

$$T = 1896 \text{ Jan. } 31.7943 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \Omega &= 208^\circ\ 47'\ 49'' \\ \omega &= 358\ \ 20\ \ 12 \\ i &= 155\ \ 42\ \ 45 \end{aligned}\right\} \text{Mean Equinox 1896.0}$$

$$q = 0.58742$$

For the middle place (O − C):

$$\Delta\lambda \cos\beta = +0''.5 \quad , \quad \Delta\beta = -0''.6$$

University of California, Students' Observatory, 1896 *Feb.* 19.

In a telegram just received, Prof. HOLDEN points out that these elements resemble those of Comet 1855 II. The following ephemeris was computed by students of the University.

$$x = [9.76025] \sin(v + 241^\circ\ 43'\ 27'') \sec^2 \tfrac{1}{2} v$$
$$y = [9.62659] \sin(v + 320\ \ 30\ \ 22) \sec^2 \tfrac{1}{2} v$$
$$z = [9.62700] \sin(v + 342\ \ 55\ \ 13) \sec^2 \tfrac{1}{2} v$$

Gr. M.T.	App. α	App. δ	log Δ	Br.
	h m s	° ′ ″		
Feb. 18.5	19 54 20.3	+ 8 45 52	9.6383	1.31
22.5	20 56 51.3	26 58 37	9.5778	
26.5	22 33 46.6	43 37 21	9.5989	
Mar. 1.5	0 22 42.0	50 59 2	9.6817	0.71

NEW ASTEROID.

Prof. KREUTZ has communicated the position of another asteroid, found photographically by Prof. WOLF, and announced by Mr. BERBERICH at Berlin.

CO 12^M 1896 Feb. 7 11^h $38^m.0$ Heidelberg M.T., $\alpha = 10^h\ 10^m\ 4^s$, $\delta = +15^\circ\ 28'$. Daily motion, -60^s in α, and 6′ northward.

COMET *a* 1896.

A telegram from Prof. KRUEGER at Kiel, received Feb. 14, brought information that PERRINE'S Comet, *c* 1895, had been observed there in the position

$$1896 \text{ Feb. } 13.7088 \text{ Gr.M.T., } \alpha = 19^{h}\,11^{m}\,17^{s}.9\,,\ \delta = -2^{\circ}\,22'\,37''$$

This position, being close to that indicated by Mr. PERRINE'S ephemeris in *A.J.* 364, was therefore not reprinted. ($\Delta\alpha = -0^{m}.1 \quad \Delta\delta = +3'$)

On Feb. 16, a dispatch from the Lick Observatory announced that the Kiel comet was a new one, and gave a position observed by Mr. PERRINE.

$$1896 \text{ Feb. } 15.0889 \text{ Gr.M.T., } \alpha = 19^{h}\,21^{m}\,57^{s}.9\,,\ \delta = -2^{\circ}\,49'\,1''$$

Other later positions followed by telegraph, being those given in Mr. PERRINE'S communication on p. 54; and immediately afterward, the Elements and Ephemeris by Messrs. LEUSCHNER and SEARES. These arrived after no. 366 had gone to press, but were communicated at once to Mr. RITCHIE who distributed them to astronomers in the "*Science Observer*" Feb. 20.

It was thus evident that two different comets had been observed; and an observation of the second, made by Dr. LAMP at Kiel, was received in season to be included in Mr. RITCHIE'S circular.

Since then, no observations have been received until today; and this number of the Journal has been delayed by a strong desire to obtain an ephemeris which should be free from the inevitable uncertainty of one dependent upon elements deduced from observations on three successive days only.

1896 *February* 28.

In reply to a telegraphic inquiry by Dr. CHANDLER, an observation by Dr. WILSON at Northfield, Minn., has now been received.

$$1896 \text{ Feb. } 21.9885 \text{ Gr.M.T., } \alpha = 20^{h}\,46^{m}\,59^{s}.8\,,\ \delta = +24^{\circ}\,30'\,6''$$

This shows the ephemeris of LEUSCHNER to have been very near the truth, on that date, the difference, O−C, being -32^{s} and $+14'$.

Using this last position, Dr. CHANDLER has now obtained from Lick observations Feb. 14, 16, and Northfield Feb. 21, the new elements and ephemeris here appended.

$$\begin{aligned} T &= 1896 \text{ Jan. } 13.76287 \\ \omega &= 358^{\circ}\,22'\,28''.9 \\ \Omega &= 208\ \ 55\ \ 51.7 \\ i &= 155\ \ 47\ \ 38.1 \\ \log q &= 9.768752 \end{aligned} \left.\begin{matrix} \\ \\ \\ \end{matrix}\right\} \text{M. Equin. } 1896.0$$

For middle place (C−O) $\Delta\lambda \cos\beta = -3''.4. \quad \Delta\beta = -5''.7$

EPHEMERIS FOR GREENWICH MIDNIGHT.

1896	App. α h m s	App. δ ° ′	log Δ	Br.
Mar. 1.5	0 23 11	+51 0.0	9.6812	0.71
3.5	1 8 39	51 45.6	.7297	.53
5.5	1 45 18	51 32.3	.7776	.40
7.5	2 11 5	50 50.2	.8231	.30
9.5	2 36 42	49 56.5	.8664	.23
11.5	2 54 41	49 0.2	.9064	.18
13.5	3 9 12	48 5.6	.9435	.14
15.5	21 10	47 14.1	9.9779	.12
17.5	31 11	46 26.8	0.0100	.10
19.5	39 41	45 43.7	.0397	.08
21.5	3 47 6	+45 4.5	0.0675	0.07

EPHEMERIS OF VARIABLES OF THE ALGOL-TYPE,

Greenwich Mean Time,

By PAUL S. YENDELL.

March		h	March		h	March		h	March		h	March		h
10	*U* Ophiuchi	13	13	*R* Canis Maj.	14	17	*U* Cephei	9	21	λ Tauri	10	24	*S* Cancri	14
11	*R* Canis Maj.	7	14	Algol	16		λ Tauri	12		*R* Canis Maj.	13		*U* Ophiuchi	19
12	*U* Cephei	9		*R* Canis Maj.	17		Algol	13		δ Librae	17		*U* Cephei	20
	R Canis Maj.	11		δ Librae	17	19	*U* Ophiuchi	18	22	*U* Cephei	9	25	λ Tauri	9
	U Coronae	13		*U* Ophiuchi	18		*U* Cephei	21		*R* Canis Maj.	16		*U* Ophiuchi	15
	Algol	20		*U* Cephei	21	20	*R* Canis Maj.	9	23	Algol	7	27	*U* Cephei	8
13	λ Tauri	13	15	*U* Ophiuchi	14		*U* Ophiuchi	15		*R* Canis Maj.	19	28	*R* Canis Maj.	8

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PUBLISHED IN BOSTON SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed February* 28.

THE

ASTRONOMICAL JOURNAL.

No. 368.

VOL. XVI. BOSTON, 1896 MARCH 11. NO. 8

JUPITER-PERTURBATIONS OF *CERES*, OF THE FIRST ORDER, AND THE DERIVATION OF THE MEAN ELEMENTS.

By G. W. HILL.

Although *Ceres* was the first discovered of the minor planets, no thoroughly adequate expressions for its absolute perturbations have ever been published, and the ephemerides of its position have been derived by the method of special perturbations. The fullest account of the discovery of this planet is contained in a paper by LALANDE (*Com. des Temps de l'année XIII*, pp. 453–465.) It is there stated that BURCKHARDT computed the perturbations in the incredibly short space of two days, and that he afterwards computed tables founded upon them. I have not been able to find this work in print, and perhaps it was never published. For some time after its discovery GAUSS busied himself with this planet (*Werke*, Band VI, pp. 199–313). He computed no less than thirteen sets of elements, and gave analytical expressions for the perturbations with tables for facilitating their computation, but did not go beyond terms of the first order with respect to the eccentricities and mutual inclination. DAMOISEAU (*Com. des Temps*, 1846, *Additions*, p. 32), has also given expressions for the perturbations. But, although a large number of terms are computed, some even of the fifth order with respect to the eccentricities and mutual inclination, the individual coefficients do not seem very exact, probably because only the term of the lowest order was taken into account; and the secular motions assigned to the eccentricity and longitude of the perihelion are much too rapid. These are the only disquisitions on this subject I am aware of.

In 1874, at the time of publishing a modified form of computing absolute perturbations (*Astr. Nachr.* no. 1982), I entered into an engagement to illustrate it by computing the first-order perturbations of *Ceres* by *Jupiter*. Considerable work was done shortly after, but other occupations hindered its completion at that time. However, I have now brought it to a conclusion, and the results are here presented.

The elements of *Ceres* and *Jupiter* employed as the basis of the work are the following:

EPOCH, 1854 JANUARY $0^d.0$.

$$\begin{aligned} \pi &= 148^\circ\ 55'\ 23''.41 & \pi' &= 11^\circ\ 58'\ 42''.2 \\ \Omega &= 80\ \ 50\ \ 50.79 & \Omega' &= 98\ \ 56\ \ 38.3 \\ i &= 10\ \ 37\ \ \ 8.54 & i' &= 1\ \ 18\ \ 39.6 \\ \varphi &= 4\ \ 24\ \ 38.41 & \varphi' &= 2\ \ 45\ \ 55.24 \\ \mu &= 769''.63875 & \mu' &= 299''.1286 \\ \log a &= 0.0000000 & \log a' &= 0.2737570 \end{aligned}$$

$$m' = {}^{1}$$

Those of *Ceres* are on the authority of ERNEST SCHUBERT (*A.J.* III, 153–159, 162–165). The computations were carried through with the stated mass of *Jupiter*, a value now antiquated; but this imperfection will be removed at the end, when the final results will be changed to suit a more modern value of this constant.

From the given elements result the following values of the mutual inclination of orbits and angular distances of the perihelia from the ascending node of *Jupiter's* orbit on the orbit of *Ceres*:

$$\mathrm{I} = 9^\circ 22' 53''.85\,,\ \ \Pi = 250^\circ 34' 28''.01\,,\ \ \Pi' = 113^\circ 35' 30''.69$$

The circumference being divided into 16 equal parts with reference to v, the true anomaly of *Ceres*, we compute the quantities K, K', A and A' for each of the points of division from the equations

$$\begin{aligned} K \cos(\Pi' - A) &= \cos(v + \Pi) \\ K \sin(\Pi' - A) &= \cos \mathrm{I} \sin(v + \Pi) \\ K' \cos(\Pi' - A') &= \cos \mathrm{I} \cos(v + \Pi) \\ K' \sin(\Pi' - A') &= \sin(v + \Pi) \end{aligned}$$

Let ζ and ζ' denote the mean anomalies severally of *Ceres* and *Jupiter*, and w' an angle such that

$$\zeta' = v - \frac{\mu'}{\mu}(v - \zeta) + w'$$

Then the circumference is divided into 24 equal parts with reference to w'. Let r and r' denote the radii of *Ceres* and *Jupiter*: h, double the areal velocity of *Ceres*, and v' the true anomaly of *Jupiter*. We compute for all combinations of the 16 values of *e*, with the 24 values of *u'*, the four following quantities:

$$\Delta^2 = 1+\left(\frac{r'}{r}\right)^2-2K\frac{r'}{r}\cos(v'+A)$$

$$X = \frac{m'}{h^2}Kr\left[\frac{1}{\Delta^3}-\left(\frac{r}{r'}\right)^3\right]r'\cos(v'+A)-\frac{m'r^2}{h^2\Delta^3}$$

$$Y = \frac{m'}{h^2}K'\left[\frac{1}{\Delta^3}-\left(\frac{r}{r'}\right)^3\right]r'\sin(v'+A')$$

$$Z = \frac{m'}{h^2}\sin I\left[\frac{1}{\Delta^3}-\left(\frac{r}{r'}\right)^3\right]r'\sin(v'+\Pi')$$

For convenience the three last are expressed in seconds of arc. For about two-thirds of the values of *u'* where *Ceres* and *Jupiter* are quite distant from each other, differencing with reference to *e* will serve as a test of their correctness. For the remaining values of *u'* they must be checked by a duplicate computation.

Mechanical quadratures are now applied to these 384 values of *X*, *Y* and *Z*, first with reference to the variable *e*, and then with reference to the variable *u'*. After these periodic series are obtained we replace *u'* by $\theta'-e$, so that the signification of θ' is given by the equation

$$\theta' = \zeta'+\frac{\mu'}{\mu}(e-\zeta)$$

whence $\frac{d\theta'}{de} = \frac{\mu'}{\mu}$. The general argument of these series is $ie+i'\theta'$, *i* and *i'* being integers. The following table gives the periodic developments of *X*, *Y*, *Z*.

Arg.		X		Y		Z	
i	*i'*	cos	sin	cos	sin	cos	sin
		″	″	″	″	″	″
0	0	+20.57678	. . .	+ 0.03455	. . .	+ 3.256	. . .
1	0	− 9.34693	− 0.64788	− 0.13276	+ 0.06894	−13.11794	− 4.48970
2	0	− 0.1197	− 0.9805	− 0.6521	+ 0.8212	+ 2.9068	+ 1.4363
3	0	+ 0.285	+ 0.439	+ 0.348	− 0.180	− 0.311	− 0.112
4	0	− 0.058	− 0.081	− 0.027	+ 0.019	+ 0.018	− 0.012
5	0	+ 0.01	+ 0.01	0.00	0.00	. . .	. . .
−4	−1	+ 0.016	+ 0.003	0.000	− 0.001	. . .	. . .
−3	−1	+ 0.124	− 0.046	+ 0.014	+ 0.029	. . .	. . .
−2	−1	− 0.491	+ 0.270	− 0.045	− 0.201	+ 0.49	+ 0.07
−1	−1	+ 0.003	− 0.540	− 0.182	+ 0.561	− 3.652	− 0.597
0	−1	+ 7.813	+ 4.269	+ 1.056	− 1.641	+ 9.640	+ 4.226
1	−1	−17.4732	−15.5278	− 4.3858	+ 4.8851	− 4.254	− 3.363
2	−1	+ 3.476	+ 2.216	− 0.429	− 0.244	+ 4.42	+ 7.85
3	−1	− 0.227	+ 1.202	+ 1.080	− 0.082	− 0.79	− 1.77
4	−1	+ 0.022	− 0.524	− 0.250	− 0.006	+ 0.11	+ 0.12
5	−1	0.000	+ 0.070	+ 0.025	− 0.001	. . .	. . .
−3	−2	+ 0.024	+ 0.007	− 0.004	+ 0.007	. . .	. . .
−2	−2	− 0.158	− 0.035	+ 0.011	+ 0.022	+ 0.01	+ 0.06
−1	−2	+ 0.498	+ 0.182	− 0.193	+ 0.111	− 0.55	− 0.55
0	−2	− 0.0673	+ 1.8213	+ 1.6813	− 0.3220	+ 2.928	+ 3.946
1	−2	− 3.5564	−17.5296	−11.6928	+ 1.5478	− 5.833	−13.083
2	−2	+ 4.7181	+57.1832	+49.4221	− 3.7845	+ 1.106	+ 4.584
3	−2	− 1.713	− 7.047	− 3.678	+ 1.367	+ 1.15	− 5.39
4	−2	+ 0.849	− 0.345	− 0.518	− 0.615	− 0.30	+ 1.07
5	−2	− 0.21	+ 0.09	+ 0.14	+ 0.13	. . .	. . .
6	−2	+ 0.02	− 0.04	− 0.01	− 0.01	. . .	. . .
−2	−3	− 0.025	− 0.024	0.000	+ 0.001	. . .	. . .
−1	−3	+ 0.133	+ 0.110	− 0.036	− 0.002	− 0.01	− 0.11
0	−3	− 0.3421	+ 0.0131	+ 0.4117	+ 0.0765	+ 0.238	+ 1.096
1	−3	+ 0.9744	− 3.6564	− 3.11454	− 0.76372	− 0.151	− 5.149
2	−3	− 6.7575	+19.4914	+15.9989	+ 6.4363	− 2.869	+ 8.918
3	−3	+22.268	−29.430	−26.060	−20.161	+ 1.52	− 2.94
4	−3	− 3.486	+ 4.038	+ 2.478	− 0.526	− 2.61	+ 1.89
5	−3	− 0.71	− 0.16	+ 0.08	+ 0.65	+ 0.51	− 0.36
6	−3	+ 0.21	− 0.03	− 0.02	− 0.13	. . .	. . .
7	−3	− 0.03	+ 0.02	0.00	+ 0.01	. . .	. . .
−1	−4	+ 0.012	+ 0.038	0.000	+ 0.003	. . .	. . .
0	−4	− 0.053	− 0.116	+ 0.050	+ 0.039	− 0.07	+ 0.16
1	−4	+ 0.3645	+ 0.2471	− 0.4406	− 0.3832	+ 0.454	− 1.149
2	−4	− 3.1579	+ 3.2819	+ 2.9694	+ 2.7147	− 2.568	+ 3.174
3	−4	+14.084	− 8.344	− 7.349	−12.076	+ 5.07	− 3.00
4	−4	−21.886	+ 4.199	+ 3.532	+19.926	− 2.05	+ 0.81
5	−4	+ 2.15	− 1.28	− 1.04	− 1.15	+ 1.86	+ 0.15
6	−4	+ 0.35	+ 0.10	+ 0.34	− 0.36	− 0.31	− 0.02
7	−4	− 0.13	− 0.07	+ 0.01	− 0.08	. . .	. . .
−1	−5	− 0.002	+ 0.007	+ 0.001	0.000	. . .	. . .
0	−5	+ 0.0092	− 0.0365	+ 0.0001	+ 0.0052	− 0.015	+ 0.009
1	−5	+ 0.0166	+ 0.0640	− 0.0406	− 0.0846	+ 0.163	− 0.154
2	−5	− 0.6539	+ 0.1132	+ 0.29957	+ 0.71839	− 0.994	+ 0.565
3	−5	+ 4.3150	− 0.6108	− 0.6302	− 3.8565	+ 2.941	− 0.506
4	−5	−11.700	− 2.142	− 1.833	+ 8.855	− 3.51	− 0.69
5	−5	+11.155	+ 6.713	+ 6.319	−10.118	+ 1.33	+ 0.48
6	−5	− 1.40	− 0.13	+ 0.16	+ 2.47	− 0.71	− 0.77
7	−5	− 0.03	− 0.37	− 0.34	+ 0.05	+ 0.13	+ 0.12
8	−5	+ 0.04	+ 0.17	+ 0.06	0.00	. . .	. . .
0	−6	+ 0.006	− 0.005	− 0.001	− 0.001	. . .	. . .
1	−6	− 0.022	+ 0.020	− 0.006	− 0.009	+ 0.028	− 0.007
2	−6	− 0.041	− 0.035	− 0.009	+ 0.125	− 0.239	+ 0.028
3	−6	+ 0.7851	− 0.0235	+ 0.2033	− 0.8253	+ 0.943	+ 0.179
4	−6	− 3.166	− 1.956	− 1.730	+ 2.910	− 1.76	− 1.09
5	−6	+ 5.01	+ 6.11	+ 5.80	− 4.58	+ 1.35	+ 1.71
6	−6	− 2.20	−10.44	− 6.57	+ 1.90	− 0.42	− 0.78
7	−6	+ 0.59	+ 0.49	+ 0.21	− 0.51	+ 0.05	+ 0.58
8	−6	− 0.13	+ 0.21	+ 0.19	+ 0.14	. . .	. . .
9	−6	0.00	− 0.19	− 0.03	− 0.03	. . .	. . .
1	−7	− 0.008	+ 0.001	+ 0.001	+ 0.001	. . .	. . .
2	−7	+ 0.017	− 0.004	− 0.008	+ 0.012	− 0.037	− 0.012
3	−7	+ 0.0646	+ 0.0679	+ 0.0936	− 0.1189	+ 0.196	+ 0.123
4	−7	− 0.495	− 0.585	− 0.654	+ 0.513	− 0.466	− 0.594
5	−7	+ 0.890	+ 2.798	+ 2.558	− 0.857	+ 0.39	+ 1.32
6	−7	+ 0.35	− 5.31	− 4.90	+ 1.26	+ 0.09	− 1.28
7	−7	− 1.73	+ 3.80	+ 3.47	+ 1.67	− 0.13	+ 0.53
8	−7	− 0.10	− 0.42	− 0.27	− 1.36	+ 0.21	− 0.24
9	−7	+ 0.13	− 0.07	− 0.02	− 0.16	. . .	. . .
10	−7	− 0.02	− 0.03	− 0.02	+ 0.02	. . .	. . .
1	−8	− 0.001	− 0.001	0.000	0.000	. . .	. . .
2	−8	+ 0.0062	+ 0.0029	− 0.0008	+ 0.0003	− 0.002	− 0.003
3	−8	− 0.0062	+ 0.0028	+ 0.0190	− 0.0150	+ 0.025	+ 0.035
4	−8	− 0.0267	− 0.1307	− 0.1593	+ 0.0433	− 0.082	− 0.184
5	−8	− 0.042	+ 0.759	+ 0.673	+ 0.025	− 0.03	+ 0.56
6	−8	+ 0.87	− 2.00	− 1.87	− 0.79	+ 0.38	− 0.81
7	−8	− 2.42	+ 2.38	+ 2.20	+ 2.25	− 0.52	+ 0.57
8	−8	+ 2.12	− 0.93	− 0.84	− 1.96	+ 0.27	− 0.18
9	−8	− 0.08	+ 0.19	+ 0.23	− 0.03	. . .	. . .
10	−8	− 0.10	+ 0.03	− 0.10	+ 0.08	. . .	. . .
2	−9	+ 0.001	+ 0.001	0.000	0.000	. . .	. . .
3	−9	− 0.0032	− 0.0045	+ 0.0018	+ 0.0004	+ 0.001	+ 0.006
4	−9	+ 0.0050	− 0.0103	− 0.0263	− 0.0040	+ 0.002	− 0.014
5	−9	− 0.068	+ 0.133	+ 0.151	+ 0.065	− 0.06	+ 0.16
6	−9	+ 0.41	− 0.46	− 0.46	− 0.41	+ 0.28	− 0.28
7	−9	− 1.41	+ 0.66	+ 0.67	+ 1.31	− 0.52	+ 0.22
8	−9	+ 2.14	− 0.10	− 0.08	− 3.11	+ 0.44	− 0.03
9	−9	− 1.20	− 0.40	− 0.35	+ 1.10	− 0.19	− 0.03
10	−9	+ 0.08	− 0.01	− 0.18	+ 1.06	. . .	. . .
11	−9	+ 0.11	− 0.02	+ 0.17	+ 0.05	. . .	. . .

Arg. *i*	*i′*	*X* cos	*X* sin	*Y* cos	*Y* sin	*Z* cos	*Z* sin
		″	″	″	″	″	″
3	—10	0.0000	— 0.0006	— 0.0002	+ 0.0001	. . .	. . .
4	—10	+ 0.0001	+ 0.0022	— 0.0025	+ 0.0018	+ 0.003	— 0.007
5	—10	— 0.0149	+ 0.0122	+ 0.0173	+ 0.0146	— 0.028	+ 0.030
6	—10	+ 0.129	— 0.062	— 0.018	— 0.135	+ 0.12	— 0.06
7	—10	— 0.51	+ 0.18	+ 0.05	+ 0.48	— 0.28	+ 0.02
8	—10	+ 1.02	+ 0.30	+ 0.28	— 0.96	+ 0.34	+ 0.11
9	—10	— 0.98	— 0.80	— 0.77	+ 0.93	— 0.22	— 0.13
10	—10	+ 0.32	+ 0.62	+ 0.52	— 0.35	. . .	. . .
11	—10	+ 0.06	— 0.05	+ 0.10	+ 0.19	. . .	. . .
4	—11	— 0.0008	+ 0.0008	0.0000	— 0.0001	. . .	. . .
5	—11	— 0.0006	— 0.0004	+ 0.0015	+ 0.0039	— 0.007	+ 0.003
6	—11	+ 0.024	— 0.023	+ 0.001	— 0.031	+ 0.04	0.00
7	—11	— 0.13	— 0.03	+ 0.09	+ 0.13	— 0.10	— 0.03
8	—11	+ 0.31	+ 0.14	+ 0.21	— 0.31	+ 0.15	+ 0.11
9	—11	— 0.38	— 0.60	— 0.58	+ 0.35	— 0.11	— 0.19
10	—11	+ 0.13	+ 0.79	+ 0.73	+ 0.32	. . .	. . .
11	—11	+ 0.16	— 0.36	— 0.32	+ 0.03	. . .	. . .
12	—11	— 0.16	— 0.10	+ 0.07	— 0.70	. . .	. . .
13	—11	+ 0.22	+ 0.20	— 0.16	+ 0.24	. . .	. . .

In order to pass from the values of these three functions to the expressions of the perturbations of the three coordinates, it is necessary to derive first the function

$$T = X + 2fr^3 + 2r^3\!\int r^{-2}\left(\frac{e\sin v}{p}X + Y\right)dv\,,$$

where p denotes the semi-parameter and f is the arbitrary constant which completes the integral of the expression. To discover the value of the latter, let X contain the terms

$$B_0 + B_1\cos v$$

and T, without the addition of $2fr^3$, the terms

Then
$$A_0 + A_1\cos v$$

$$f = -\frac{1}{6ap^2}\left[3A_0 + B_0 + \frac{e}{2}(3A_1 + B_1) + \tan\frac{\varphi}{2}\cos^2\varphi\,.\,A_1\right]$$

In the present case we have

$$A_0 = +20''.96790 \quad , \quad B_0 = +20''.57678\,,$$
$$A_1 = -12''.75542 \quad , \quad B_1 = -9''.34693,$$

consequently

$$f = -13''.68833$$

The perturbations of the radius, of the orbit-longitude, and a latitude referred to the plane of the primitive orbit, are then given by the equations

$$\delta r = \int T\sin(\bar{v} - v)\,dv$$
$$\delta\lambda = \int\left[\int Y dv - 2\,\frac{\delta r}{r}\right]dv$$
$$\delta\beta = \int Z\sin(\bar{v} - v)\,dv$$

where $\bar{v}$ denotes a v invariable in the integration which afterwards is to be made equal to v.

In integrating the perturbation of the radius δr contains the portion

$$K^{(c)}\cos v + K^{(s)}\sin v$$

depending on arbitrary constants. In order to make the terms involving the argument v disappear from the perturbation of the orbit longitude $\delta\lambda$, we must put

$$K^{(c)} = +3''.6988 \quad , \quad K^{(s)} = +0''.4188$$

After the integration is accomplished we substitute for the v, which appears as a multiplier of coefficients, its value given by the infinite series

$$v = nt + E_1\sin v - \tfrac{1}{2}E_2\sin 2v + \tfrac{1}{3}E_3\sin 3v - \ldots$$

where

$$E_i = 2\left(1 + i\sqrt{1-e^2}\right)\left(\frac{e}{1+\sqrt{1-e^2}}\right)^i$$

Before the integration was performed it was discovered that the μ of the osculating elements for 1854 Jan. 1 differed widely from the mean value. In integrating, therefore, the value $\mu = 770''.75$ was assumed, and the mass of *Jupiter* was put at $\frac{1}{1047.355}$. The following table gives the expressions for the perturbations, those of the common logarithm of the radius being in units of the seventh decimal:

Arg. *i*	*i′*	δλ sin	δλ cos	δ(log *r*) cos	δ(log *r*) sin	δβ sin	δβ cos
		″	″			″	″
0	0	. . .	. . .	— 138.3	. . .	. . .	+ 2.75
. .	.	. . .	. . .	+ 0.4127*nt*	. . .	. . .	. . .
1	0	. . .	. . .	+ 68.0	+ 9.3	. . .	. . .
. .	.	— 1.01940*nt*	— 6.51277*nt*	+ 10.7318*nt*	— 68.5658*nt*	— 6.72591*nt*	+ 2.25052*nt*
2	0	— 1.05	+ 0.77	+ 13.8	+ 12.1	— 0.31	— 0.45
. .	.	— 0.01960*nt*	— 0.12522*nt*	+ 0.4127*nt*	— 2.6364*nt*	. . .	. . .
3	0	+ 0.06	— 0.09	— 0.9	— 1.5	+ 0.01	+ 0.02
—3	—1	— 0.01	0.00	— 0.2	+ 0.1	. . .	. . .
—2	—1	+ 0.14	+ 0.05	+ 2.7	— 0.9	— 0.01	— 0.10
—1	—1	— 0.54	— 1.18	— 3.6	+ 18.6	+ 0.65	+ 3.95
0	—1	+ 41.31	— 29.74	+ 124.2	+ 92.8	+ 4.99	+11.38
1	—1	+162.88	—146.19	—1133.5	—1017.4	— 5.39	— 6.82
2	—1	+ 7.35	— 5.09	— 123.1	— 89.2	— 4.92	— 2.77
3	—1	+ 0.07	— 0.47	— 1.5	— 8.6	+ 0.30	+ 0.14
4	—1	0.00	+ 0.05	0.0	+ 1.0	— 0.01	— 0.01
—2	—2	+ 0.01	— 0.01	+ 0.3	+ 0.1	— 0.01	0.00
—1	—2	— 0.22	— 0.85	— 3.4	+ 17.1	+ 0.26	+ 0.25
0	—2	+ 5.10	— 44.13	+ 37.3	+ 337.8	+ 9.95	+ 7.38
1	—2	+107.73	—600.51	— 326.8	—1966.3	—13.81	— 6.16
2	—2	+ 43.06	—514.81	— 522.1	—6206.4	— 9.23	— 2.23
3	—2	— 0.26	— 5.05	— 0.4	— 135.8	+ 1.37	— 0.29
4	—2	+ 0.13	+ 0.15	— 2.4	+ 3.3	— 0.11	+ 0.03
5	—2	— 0.01	— 0.01	+ 0.3	— 0.2	. . .	. . .
—1	—3	— 0.01	— 0.09	— 0.2	+ 2.2	+ 0.03	0.00
0	—3	+ 1.27	— 8.76	+ 16.3	+ 103.6	— 3.09	— 0.67
1	—3	+ 10.62	— 65.53	— 30.7	+ 313.4	— 5.30	— 0.16
2	—3	+143.46	+396.34	—1343.5	+3689.0	+29.64	— 9.54
3	—3	+ 29.57	+ 43.22	— 455.6	+ 685.5	+ 1.24	— 0.64
4	—3	+ 0.06	— 0.48	+ 0.3	— 5.0	— 0.27	+ 0.37
5	—3	— 0.09	— 0.01	+ 1.9	— 0.3	+ 0.03	— 0.04
6	—3	+ 0.01	0.00	— 0.2	0.0	. . .	. . .
0	—4	+ 0.09	— 0.10	+ 1.8	+ 1.3	— 0.11	+ 0.05
1	—4	+ 3.45	+ 1.61	+ 12.7	— 0.9	— 1.66	+ 0.65
2	—4	+ 51.89	+ 65.22	— 308.5	+ 377.4	+ 3.98	— 3.22
3	—4	+ 44.38	+ 28.87	— 588.3	+ 386.4	+ 2.75	— 4.64
4	—4	— 8.99	— 1.36	+ 145.6	— 19.8	— 0.16	+ 0.41
5	—4	+ 0.15	+ 0.17	— 2.1	+ 3.0	— 0.01	— 0.17
6	—4	+ 0.03	— 0.03	— 0.7	— 0.5	0.00	+ 0.02
0	—5	+ 0.44	+ 0.27	+ 9.0	— 5.5	0.00	+ 0.01
1	—5	+ 21.22	+ 13.45	+ 209.2	— 132.7	— 1.34	+ 1.41
2	—5	+297.15	+193.91	— 313.6	+ 174.6	+ 0.57	— 1.00
3	—5	+184.80	+ 45.15	—2022.8	+ 497.3	+ 4.14	—24.06
4	—5	— 4.64	+ 2.30	+ 55.2	+ 40.5	+ 0.21	+ 1.09
5	—5	+ 2.38	— 1.51	— 41.8	— 26.9	— 0.06	— 0.16
6	—5	— 0.21	— 0.02	+ 2.6	— 0.5	+ 0.05	+ 0.05
7	—5	0.00	+ 0.02	+ 0.1	+ 0.4	0.00	— 0.01

Arg. *i*	*i′*	δλ sin	δλ cos	δ(log *r*) cos	δ(log *r*) sin	δβ sin	δβ cos
		″	″			″	″
1	−6	+ 0.08	+0.07	+ 1.1	− 0.9	+0.01	−0.04
2	−6	+ 0.15	+0.24	+ 4.5	− 0.5	+0.03	−0.27
3	−6	−12.82	+1.02	+103.6	+10.4	+0.33	+1.72
4	−6	− 5.61	+3.05	+ 80.4	+12.8	+0.61	+0.98
5	−6	+ 1.60	−2.03	− 26.8	−34.2	−0.28	−0.22
6	−6	− 0.27	+1.08	+ 4.8	+23.0	+0.06	+0.03
7	−6	+ 0.01	−0.01	− 0.7	− 0.4	−0.03	0.00
8	−6	− 0.01	−0.01	+ 0.1	− 0.2	. . .	. . .
2	−7	− 0.15	+0.17	− 1.0	− 1.1	−0.02	−0.08
3	−7	− 3.63	+2.37	+ 15.3	+10.6	+0.13	+0.21
4	−7	− 3.43	+3.80	+ 42.1	+46.0	+0.92	+0.72
5	−7	+ 0.46	−1.42	− 7.0	−22.4	−0.31	−0.09
6	−7	− 0.14	+0.95	+ 0.9	+17.0	+0.13	−0.01
7	−7	− 0.16	−0.33	+ 3.1	− 6.2	−0.03	+0.01
8	−7	+ 0.05	+0.01	− 0.3	+ 0.3	+0.01	+0.01
9	−7	+ 0.01	0.00	− 0.1	+ 0.1	. . .	. . .
2	−8	− 0.24	+0.10	− 2.8	− 1.1	+0.01	+0.01
3	−8	− 2.90	+0.92	− 4.7	− 2.9	+0.04	+0.03
4	−8	+ 1.11	−4.17	− 11.0	−41.2	−0.93	−0.41
5	−8	+ 0.01	−0.83	− 0.4	−12.7	−0.22	+0.01
6	−8	+ 0.22	+0.51	− 3.7	+ 8.8	+0.11	−0.05
7	−8	− 0.27	−0.27	+ 5.1	− 5.0	−0.04	+0.04
8	−8	+ 0.13	+0.06	− 2.6	+ 1.1	+0.01	−0.01
9	−8	0.00	−0.01	0.0	− 0.1	. . .	. . .
3	−9	−0.01	−0.01	− 0.1	0.0	+0.01	0.00
4	−9	−0.02	−0.33	+ 0.2	− 2.3	−0.06	0.00
5	−9	−0.16	−0.39	+ 2.0	− 5.1	−0.12	+0.05
6	−9	+0.17	+0.19	− 2.7	+ 3.0	+0.05	−0.05
7	−9	−0.21	−0.11	+ 3.8	− 1.9	−0.02	+0.05
8	−9	+0.23	+0.01	− 3.7	+ 0.1	0.00	−0.02
9	−9	−0.06	+0.02	+ 1.1	+ 0.4	0.00	+0.01
10	−9	−0.03	0.00	+ 0.2	0.0	. . .	. . .
3	−10	+0.06	−0.02	+ 0.6	+ 0.2	. . .	. . .
4	−10	+0.61	−0.16	− 0.9	− 0.4	−0.01	0.00
5	−10	−0.17	−0.30	+ 1.9	− 3.3	−0.12	+0.11
6	−10	+0.09	+0.02	− 1.3	+ 0.3	+0.02	−0.03
7	−10	−0.11	−0.02	+ 1.8	− 0.5	0.00	+0.03
8	−10	+0.10	−0.03	− 1.9	− 0.5	−0.01	−0.02
9	−10	−0.06	+0.05	+ 1.1	+ 0.9	0.00	+0.01
10	−10	+0.01	−0.02	− 0.2	− 0.4	. . .	. . .
4	−11	0.00	−0.01	. . .	. . .	. . .	. . .
5	−11	+0.04	+0.01	− 0.3	+ 0.1	+0.01	−0.02
6	−11	+0.04	+0.01	− 0.6	+ 0.3	0.00	−0.02
7	−11	−0.04	−0.02	+ 0.7	− 0.1	0.00	+0.02
8	−11	+0.01	−0.02	− 0.7	− 0.4	−0.01	−0.01
9	−11	−0.03	+0.01	+ 0.5	+ 0.8	+0.01	+0.01
10	−11	−0.01	−0.03	0.0	− 0.7	. . .	. . .
11	−11	0.00	+0.01	− 0.1	+ 0.2	. . .	. . .
12	−11	+0.01	0.00	. . .	. . .	. . .	. . .

In order to arrive at mean elements for *Ceres*, as well as to see how closely the preceding perturbations were capable of representing the heliocentric coordinates of the planet, 10 normal positions were formed for the times of as many oppositions from material as follows:

Opposition of 1802 — Derived from 4 observations at Greenwich on Mar. 6, 14, 18, 25.
" " 1807 — Derived from Gauss's *Werke*, VI, 299.
" " 1830 — Derived from 5 observations at Greenwich on Apr. 27, 28, 30; May 1, 3.
" " 1857 — Derived from 4 observations at Greenwich on Feb. 16, 24, 26, 28.
" " 1863 — Derived from 5 observations at Greenwich on July 6, 9, 10, 16, 18.
Opposition of 1866 — Derived from 3 observations at Greenwich, 1 at Paris on Jan. 22, 23, 24; Feb. 2.
" " 1873 — Derived from 4 observations at Greenwich, 3 at Paris on Sept. 19, 20, 23, 26, 27; Oct. 2, 6.
" " 1883 — Derived from 8 observations at Greenwich on Nov. 23, 26, 27, 29; Dec. 4, 5, 14, 15.
" " 1885 — Derived from eleven observations at Greenwich on Mar. 27, 28, 30, 31; Apr. 2, 4, 6, 11, 16, 17, 18.
" " 1890 — Derived from 7 observations at Greenwich on May 14, 15, 21, 22, 23, 24, 26.

The normals, with certain additional data, are

Greenwich M.T.	Hel. Long. M.E. of Date	Geoc. Lat.	Log. Earth's Radius	*v*
d	° ′ ″	° ′ ″		° ′ ″
1802 Mar. 17.15072	176 21 32.3	+17 7 57.2	9.9982161	27 22 46.0
1807 May 3.14789	222 13 53.8	+10 40 15.9	0.0038415	72 47 3.6
1830 Apr. 30.32003	219 55 21.2	+11 11 24.4	0.0035208	70 37 38.6
1857 Feb. 13.77639	145 34 58.1	+15 36 20.0	9.9947561	357 15 27.9
1863 July 16.16898	293 33 38.9	− 8 49 22.5	0.0070483	144 41 38.8
1866 Jan. 20.79681	121 5 35.9	+11 9 43.7	9.9931177	332 20 44.7
1873 Sept. 23.34662	0 51 22.7	−15 45 57.5	0.0011276	211 24 17.1
1883 Dec. 6.86562	74 57 7.3	− 1 44 29.6	9.9933823	285 41 43.1
1885 Apr. 2.34757	193 15 32.4	+15 51 21.8	0.0001720	43 6 40.2
1890 May 17.37448	236 51 47.4	+ 6 53 49.4	0.0051454	86 39 46.0

	ϑ′	δλ	δ log *r*	δβ
	° ′ ″	′ ″		″
1802	139 25 1.0	+22 36.9	− 5035	− 3.3
1807	296 45 10.8	+24 33.2	+ 7507	+59.9
1830	271 31 6.4	− 1 7.6	+ 8938	+58.6
1857	4 20 30.5	−17 5.9	− 6064	−34.8
1863	201 16 52.6	+11 56.4	+ 6398	+23.9
1866	274 6 12.9	+12 23.9	−10719	−43.4
1873	146 35 49.7	+11 13.2	− 6087	−10.4
1883	94 51 25.5	+ 26.1	− 8011	−69.5
1885	140 26 1.5	+22 49.0	+ 1114	+22.6
1890	297 3 7.8	+15 32.9	+ 9161	+77.9

The *Earth's* radius is corrected for its latitude according to the precept of GAUSS (*Theoria Motus*, Art. 72.) To θ' are added the long-period inequalities of the mean longitude of *Jupiter*. The values of the perturbations given in the last columns contain only the periodic terms; that of $\log r$ is in units of the seventh decimal. The terms due to the action of *Mars* and *Saturn* were computed from the formulas of DAMOISEAU.

The secular perturbations through the action of *Mars*, *Jupiter* and *Saturn* were computed by the method of GAUSS, the values of the attracting masses being severally $\frac{1}{3093500}$, $\frac{1}{1047.355}$, $\frac{1}{3501.6}$. The results obtained are annexed to the following system of elements, which is that compared with the foregoing normals. The secular motions of π, Ω and i include the effect of precession and motion of the ecliptic. The adopted value of general precession for 1850 is 50″.25787.

Epoch, 1850 Jan. 0.0 G.M.T.

$$L = 309^\circ\ 30'\ 36''.7$$
$$\pi = 148\ 23\ 18.1 + 106''.6658\,t$$
$$\Omega = 80\ 50\ 45.0 \quad - 4.9064\,t$$
$$i = 10\ 37\ 10.1 \quad - 0.5676\,t$$
$$e = 0.0784500 - 0.0000033317\,t$$
$$\mu = 770''.72275$$
$$\log a = 0.4120721$$

The residuals left by the comparison of these elements with the normals are (Obs.—Cal.).

	Hel. Long.	Geoe. Lat.		Hel. Long.	Geoe. Lat.
	″	″		″	″
1802	+ 50.0	— 6.2	1866	— 41.9	+24.7
1807	+ 64.5	—36.5	1873	+ 1.4	+21.2
1830	— 8.7	—30.6	1883	— 86.1	+29.3
1857	—112.3	— 3.6	1885	—132.2	— 9.7
1863	— 3.1	—31.2	1890	— 43.4	—41.6

The equations of condition for correcting the assumed elements follow. The final terms of those which arise from the longitudes are made to be residuals in geocentric longitude multiplied by the cosine of the geocentric latitude. For convenience, 40 Julian years is the unit of time for δn; and logarithms are written in place of the coefficients and final terms.

	δL	δn	δe	$e\delta\pi$	δi	$\sin i\,\delta\Omega$			
1802	0.2672	0.3445*n*	0.2115	0.4953*n*	8.4476	9.1657*n*	1.8969*n*	=	0
1807	0.2183	0.2463*n*	0.4881	0.0219*n*	9.1591	8.4948	2.0072*n*	=	0
1830	0.2218	9.9136*n*	0.4832	0.0777*n*	9.1653	8.2980	1.1371	=	0
1857	0.2752	9.5258	9.1437*n*	0.5506*n*	9.0604*n*	8.9829*n*	2.2512	=	0
1863	0.1233	9.6528	0.2255	0.3470	9.1107*n*	8.7608	0.6714	=	0
1866	0.2651	9.8687	0.2068*n*	0.4965*n*	9.1698*n*	8.3681	1.8261	=	0
1873	0.1189	9.8921	0.1796*n*	0.3641	8.6749	9.1163*n*	0.3141*n*	=	0
1883	0.2123	0.1409	0.4831*n*	0.0063*n*	8.4786	9.1571	2.1329	=	0
1885	0.2557	0.2008	0.3524	0.4166*n*	9.0183	9.0255*n*	2.3191	=	0
1890	0.2006	0.2047	0.4968	9.5788*n*	9.0397	8.9905	1.8349	=	0
1802	8.6001*n*	8.6774	9.1570	9.1793	0.2006	9.1811	0.7924	=	0
1807	9.3875*n*	9.4155	9.6191*n*	9.4182	9.9952	0.0921	1.5623	=	0
1830	9.3848*n*	9.0766	9.5902*n*	9.4489	0.0162	0.0778	1.4857	=	0
1857	9.1716	8.4222	9.2357	9.4569*n*	0.1608	9.8347*n*	0.5563	=	0
1863	9.3113*n*	8.8408*n*	9.3040*n*	9.5934*n*	9.9144*n*	0.1066	1.4942	=	0
1866	9.4239	9.0275	9.0576*n*	9.7023*n*	0.0161	0.0884*n*	1.3927*n*	=	0
1873	8.5646	8.3378	8.7992	9.1512	0.1667*n*	9.4141*n*	1.3263*n*	=	0
1883	9.4808	9.4094	9.7573*n*	9.2342*n*	9.2080*n*	0.1956*n*	1.4669*n*	=	0
1885	9.1333*n*	9.0784*n*	8.4282*n*	9.4843	0.1678	9.7837	0.9868	=	0
1890	9.4417*n*	9.4458*n*	9.7255*n*	9.1310	9.8069	0.1592	1.6191	=	0

With equal weights, these 20 equations produce the normal equations

δL	δn	δe	$e\delta\pi$	δi	sln $i\,\delta\Omega$	″		
28.232	+ 3.028	+14.472	—23.316	— 0.031	— 2.473	+ 826.0	=	0
+ 3.028	+17.398	— 8.914	+ 2.845	+ 0.014	— 0.301	+1068.6	=	0
+14.472	— 8.914	+54.309	—10.240	+ 0.716	— 1.276	— 286.3	=	0
—23.316	+ 2.845	—10.240	+53.884	+ 0.465	+ 2.198	—1179.9	=	0
— 0.031	+ 0.014	+ 0.716	+ 0.465	+13.300	+ 1.850	+ 95.5	=	0
— 2.473	— 0.301	— 1.276	+ 2.198	+ 1.850	+11.657	+ 265.5	=	0

Their solution gives the corrections and corrected elements:

$$\begin{aligned} \delta L &= -4''.3 \\ \delta\mu &= -0''.001474 \\ \delta e &= -0''.00000115 \\ \delta\pi &= +5'\ 14''.4 \\ \delta i &= -\ \ \ 3''.9 \\ \Omega\,\delta &= -2'\ 39''.4 \end{aligned}$$

Epoch 1850 Jan. $0^d.0$ G.M.T.

$$\begin{aligned} L &= 309^\circ\ 30'\ 32''.4 \\ \pi &= 148\ \ 28\ \ 32.5 \\ \Omega &= 80\ \ 18\ \ \ 5.6 \\ i &= 10\ \ 37\ \ \ 6.2 \\ e &= 0.07814855 \\ \mu &= 770''.718276 \\ \log a &= 0.4120738 \end{aligned}$$

The residuals left by this solution in heliocentric longitude and geocentric latitude, as they result from the equations of condition, are (Obs. Calc.),

	Hel. Long.	Geoc. Lat.		Hel. Long.	Geoc. Lat.
	″	″		″	″
1802	+10.0	+ 3.7	1866	+41.4	+13.2
1807	+13.9	+13.0	1873	− 1.8	+ 9.5
1830	−18.1	+ 8.3	1883	− 6.3	+ 4.7
1857	−40.2	− 8.6	1885	−22.0	− 0.1
1863	−15.0	+ 7.3	1890	+36.0	−19.7

They are larger than one would be inclined to attribute to the neglect of the square of the disturbing force. However, the derived mean elements, on account of the long period of time embraced, will have some value.

RELATIVE POSITIONS OF *TETHYS* AND *RHEA*,

OBSERVED WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY ORMOND STONE.

The angles here given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction.

1894	Eastern Time	*p*	Eastern Time	*s*
	h m s	°	h m s	″
Mar. 13	14 31 25	265.15	. . .	. .
19	16 19 48	78.22	. . .	. .
21	11 48 50	252.80	12 6 28	24.39
	12 58 20	251.48	12 11 22	23.96
23	13 1 51	58.99	13 10 7	56.18
26	11 6 52	261.68	12 4 8	120.76
27	10 19 0	330.36	10 40 31	20.14
30	10 30 11	256.29	10 56 2	76.74
Apr. 6	9 43 26	83.83	9 50 26	54.59
	10 0 26	84.24	9 56 13	54.89
8	10 30 26	232.98	10 51 26	52.41
	11 15 6	238.23	. . .	. .
14	13 28 21	279.72	13 56 59	90.46
	. . .	. . .	13 58 43	89.86
16	15 24 42	93.84	15 36 30	30.84
	. . .	. . .	15 38 25	30.67
26	8 27 52	149.64	8 48 36	8.94
27	9 5 21	263.10	9 12 10	108.65
	9 18 33	263.15	9 13 35	108.57
29	13 43 30	81.49	13 52 36	36.70
	14 2 1	84.28	13 54 34	36.35
30	13 57 33	104.26	14 3 39	70.46
	14 12 57	104.92	14 5 19	70.40
May 1	8 50 4	259.73	. . .	. .
3	7 54 55	316.89	8 2 37	21.14
	8 9 50	319.65	8 4 27	20.97
9	8 50 45	95.43	9 0 5	32.48
	9 6 39	95.46	9 1 57	32.43
10	8 47 26	243.25	8 53 2	55.28
	9 1 53	244.48	8 54 47	55.51
15	10 26 6	271.37	10 32 39	43.28
	10 42 44	274.30	10 36 34	43.40
June 1	10 41 22	107.48	10 52 49	34.66
	11 6 4	108.42	10 58 7	34.74
3	10 48 27	52.05	10 54 3	28.60
	11 3 53	53.76	10 55 42	28.49
4	9 52 44	70.75	9 56 14	26.19
	10 4 45	71.07	10 0 6	26.09

1895	Eastern Time	*p*	Eastern Time	*s*
	h m s	°	h m s	″
April 5	14 5 41	241.89	14 41 16	46.61
	14 12 3	242.78	15 10 48	48.95
10	15 23 42	295.71	15 30 22	49.48
	. . .	. . .	15 42 42	48.36
11	13 1 31	342.05	13 15 4	11.91
	13 6 52	340.16	13 18 39	11.95
	13 9 19	340.11	13 22 27	12.18
	14 10 9	334.63	14 32 44	13.13
	14 12 59	334.43	15 30 7	15.31
	14 21 24	333.01	15 45 51	14.62
	14 26 17	331.99	15 58 37	14.94
	15 39 4	328.19	16 22 24	15.21
	16 16 22	327.29	16 25 17	15.32
	16 29 22	326.52	. . .	. .
13	13 4 25	164.98	14 12 10	35.01
	13 8 32	166.12	14 17 17	35.24
	13 12 35	167.00	. . .	. .
	13 19 27	168.88	. . .	. .
	13 23 8	170.26	. . .	. .
	13 26 51	171.18	. . .	. .
	13 30 20	172.11	. . .	. .
	13 34 10	173.31	. . .	. .
	13 37 21	173.50	. . .	. .
	13 48 37	176.66	. . .	. .
	13 52 4	177.76	. . .	. .
	13 55 58	178.55	. . .	. .
17	13 17 40	120.44	14 0 50	29.84
	13 51 4	120.51	14 7 0	29.47
20	10 53 57	51.33	11 11 49	41.59
	11 0 22	51.97	11 13 30	41.45
	11 39 20	55.81	11 17 30	41.66
	11 46 40	56.40	11 20 22	42.06
	. . .	. . .	11 29 50	42.38
May 4	9 31 8	357.80	9 36 9	13.25
	9 42 14	357.71	9 38 33	13.39
June 2	10 57 52	154.27	. . .	. .
	11 2 45	152.91	. . .	. .
	11 7 24	153.63	. . .	. .
	11 11 10	151.91	. . .	. .
	11 17 8	152.24	. . .	. .
	11 23 35	150.65	. . .	. .
	12 26 13	146.01	. . .	. .
3	8 57 54	255.67	. . .	. .

OBSERVATIONS OF VARIABLE STARS IN 1895,

BY WALTER J. GILL, JR.

103. *T Andromedae.*

I have eleven observations, from Aug. 18 to Oct. 8. On the first-named date it was about 8^{M}.8. It rose pretty rapidly to a maximum of 7^{M}.8, which is indicated on Sept. 1, and then decreased more slowly till the last observation, when it was about 9^{M}.1.

906. *R Trianguli.*

From Aug. 25 to 1896 Jan. 18, I have twenty-four observations. At the first observation it was about 9^{M}.7. It rose rapidly to a maximum of 5^{M}.5, Nov. 11, and decreased more slowly till the last observation, when it was 9^{M}.0.

4557. *S Ursae Majoris.*

I have two series of observations of this star. The first series, consisting of fourteen observations began on Jan. 17, with the variable about 9^{M}.8, and ended on May 23, when it was 10^{M}.1. These observations indicate a maximum of 8^{M}.2 on Mar. 21.

The second series began on Aug. 8 with the variable about 10^{M}.8, and consists of twenty-three observations, the last being on Jan. 23, 1896, when its light was 10^{M}.0. By these observations a maximum of 8^{M}.5 is indicated on Nov. 2.

5194. *V Bootis.*

From March 17 to Oct. 10, I have sixteen observations. At the first it was about 7^{M}.8. It decreased slowly to a minimum of 9^{M}.1, July 30, and then rose more rapidly till Oct. 10, when it was about 7^{M}.7.

6512. *T Herculis.*

Twelve observations, from Sept. 3 to Oct. 24, indicate a maximum of 8^{M}.1, Sept. 28. Its light at the first observation was about 9^{M}.5, at the last about 7^{M}.2.

7085. *RT Cygni.*

I have twenty observations of this star. At the first, on May 10, it was about 10^{M}. It then rose steadily to a maximum of 7^{M}.2, July 18, and decreased more quickly to 10^{M}.2, Sept. 1.

7560. *R Vulpeculae.*

Seven observations, from Sept. 5 to Oct. 5, indicate a well-defined maximum of 8^{M}.3, on Sept. 18. Its light at the first observation was 8^{M}.5, at the last 8^{M}.6. The light-curve, as drawn from my observations, is very regular, with equal times of increase and decrease.

8324. *V Cassiopeae.*

A maximum of 7^{M}.3 is indicated on Oct. 22, by twelve observations, from Sept. 13 to Dec. 8. At the first observation its light was about 9^{M}.3, at the last about 9^{M}.7. The times of increase and decrease are about equal.

Roxbury, Mass., 1896 *February* 1.

RELATIVE POSITIONS OF *TETHYS* AND *DIONE*,

OBSERVED WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY E. O. LOVETT.

The angles here given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction.

1894	East. Stand. Time	*p*	East. Stand. Time	*s*
	h m s	°	h m s	″
Mar. 6	16 40 29	102.21	17 5 7	45.17
	17 54 21	106.42	17 7 45	44.70
8	13 8 52	82.12	13 45 46	92.41
12	16 51 21	239.56	. . .	. .
	17 53 52	246.57	. . .	. .
13	16 44 56	347.76	17 37 24	23.66
	17 31 54	9.31	17 39 54	23.87
14	16 30 55	113.13	. . .	. .
15	12 39 15	271.61	14 49 35	79.41
	14 44 11	276.37	. . .	. .
18	12 29 57	261.03	12 44 39	46.91
	13 3 40	262.44	12 47 29	46.65
21	17 6 27	58.52	17 15 33	40:55
	17 30 37	61.09	. . .	. .
22	16 45 35	151.04	. . .	. .
23	15 21 26	267.70	17 16 20	13.17
	17 10 36	265.13	17 22 22	13.11
26	14 39 56	269.95	15 14 8	105.56
Mar. 26	15 7 11	270.56	15 18 32	105.59
29	16 35 14	296.28	16 41 51	4.57
30	13 9 29	63.02	13 14 7	22.51
	13 22 12	63.48	13 17 55	22.44
Apr. 2	13 55 38	101.83	13 59 59	69.26
	14 9 7	102.78	14 2 3	69.09
4	12 18 2	82.29	12 21 14	18.37
	12 26 1	82.34	12 23 21	18.23
8	16 27 56	254.50	16 35 20	67.00
	16 56 43	254.93	16 40 52	67.58
15	8 39 45	68.85	8 43 41	47.53
	8 51 7	69.52	8 46 45	47.44
	11 53 29	79.02	11 56 12	62.77
	12 2 43	79.49	11 59 7	62.85
19	9 14 39	109.44	9 18 41	51.88
	9 23 2	109.62	9 20 23	52.08
24	14 52 2	90.04	14 57 9	75.28
	15 19 36	90.50	15 3 10	75.31
25	14 15 43	268.99	14 20 47	97.87
	14 27 21	269.27	14 23 43	97.83
26	10 54 28	64.07	10 56 56	52.00
	11 1 54	65.37	10 58 36	51.84
	13 58 49	76.74	14 2 10	77.29

1894	East. Stand. Time	p	East. Stand. Time	s
	h m s	°	h m s	″
Apr. 26	11 8 28	77.33	14 1 13	77.34
27	12 16 28	229.79	12 50 11	27.35
	12 56 5	231.79	12 52 51	28.00
	15 15 17	250.20	15 18 31	42.75
	15 26 0	219.80	15 21 1	12.68
Apr. 28	10 15 47	291.86	10 49 18	21.70
	10 55 8	291.07	10 51 25	21.71
29	7 17 12	16.22	7 50 38	3.63
	7 51 2	11.06	7 51 51	3.52
	8 59 1	11.28	9 1 45	3.79
	9 5 39	42.11	9 3 34	3.86
May 1	12 27 11	276.98	12 31 6	80.89
	12 35 11	277.14	12 32 52	80.88
2	12 18 36	91.45	12 23 0	102.87
	12 29 16	91.45	12 25 52	102.85
3	12 32 15	266.85	12 35 6	83.45
	12 40 31	267.17	12 36 11	83.41
9	12 40 0	288.29	12 42 36	46.60
	12 47 11	288.23	12 41 15	46.51
10	12 15 53	96.41	12 18 21	39.14
	12 52 20	96.87	12 50 11	38.98
	11 0 37	99.83	11 4 57	31.28
	11 9 55	99.01	11 7 27	31.20
12	9 59 18	267.69	10 2 27	55.60
	10 7 56	267.76	10 5 1	55.79
13	12 22 29	86.07	12 24 49	93.32
	12 29 16	85.96	12 27 6	93.34
	13 41 34	87.75	. . .	. .
16	10 52 5	169.80	10 54 47	10.98
May 16	11 0 21	173.59	10 56 14	11.01
17	12 4 43	261.85	12 9 41	13.70
	12 13 10	261.82	12 11 32	13.65
	13 15 25	261.81	13 19 10	13.89
	13 35 12	264.64	13 27 35	14.07
21	9 3 33	86.39	9 5 58	92.34
	9 9 11	86.59	9 7 48	92.38
23	9 15 31	309.44	9 20 22	3.31
	9 26 23	310.01	9 22 45	3.35
24	11 14 26	78.59	11 17 19	41.62
	11 21 36	78.89	11 19 13	41.55
28	13 4 3	289.74	. . .	. .
29	12 22 39	82.19	12 21 51	12.61
	12 29 34	81.75	12 27 1	12.49
June 2	10 30 57	256.14	10 33 47	68.56
	10 38 45	256.59	10 36 3	68.76
7	9 47 19	97.21	9 50 7	78.19
	9 53 7	97.14	9 50 17	78.25
	11 29 9	101.22	11 32 21	65.24
	11 37 31	101.67	11 35 39	65.33
10	9 29 11	75.73	9 32 16	15.30
	9 38 31	76.06	9 34 19	15.39
11	9 17 38	262.97	9 19 31	30.88
	9 22 17	262.69	9 21 13	31.04
21	8 51 36	134.24	8 54 6	18.21
	8 58 31	136.64	8 55 57	18.19
	11 2 0	191.07	11 6 58	14.65
	11 12 6	194.64	11 9 24	11.53

EPHEMERIS OF VARIABLES OF THE ALGOL-TYPE.

Greenwich Mean Time,

By PAUL S. YENDELL.

March		h
28	δ Librae	16
	U Coronae	20
29	λ Tauri	8
	R Canis Maj.	12
	U Cephei	20
	U Ophiuchi	20
30	*R* Canis Maj.	15
	U Ophiuchi	16
April		
1	*U* Cephei	8
2	*Y* Cygni	14
3	*S* Cancri	2
	Algol	18
	U Ophiuchi	21

April		h
4	δ Librae	16
	U Coronae	17
5	*Y* Cygni	14
6	*U* Cephei	8
	R Can. Maj.	10
	Algol	15
7	*R* Can. Maj.	14
8	*Y* Cygni	14
9	Algol	12
	U Ophiuchi	18
10	*U* Ophiuchi	14
11	*Y* Cygni	14
	U Coronae	15
	δ Librae	16
12	Algol	9

April		h
12	*S* Cancri	13
13	*U* Cephei	19
14	*R* Can. Maj.	9
	Y Cygni	14
	U Ophiuchi	17
15	*R* Can. Maj.	13
17	*Y* Cygni	14
18	*U* Coronae	13
	δ Librae	15
	U Cephei	19
19	*U* Ophiuchi	19
20	*Y* Cygni	14
	U Ophiuchi	15
21	*R* Can. Maj.	11
22	*S* Cancri	1

April		h
23	*Y* Cygni	13
	U Cephei	18
25	*U* Coronae	10
	δ Librae	15
	U Ophiuchi	16
26	*Y* Cygni	13
	Algol	17
28	*U* Cephei	18
29	*Y* Cygni	13
	Algol	13
30	*U* Ophiuchi	17
May		
1	*S* Cancri	13
	U Ophiuchi	13

May		h
2	*U* Ophiuchi	9
	Y Cygni	13
	δ Librae	14
3	*U* Cephei	18
5	*Y* Cygni	13
	U Coronae	11
6	*U* Ophiuchi	11
7	*U* Ophiuchi	10
8	*Y* Cygni	13
	U Cephei	17
9	δ Librae	14
10	*U* Ophiuchi	18
11	*S* Cancri	0
	Y Cygni	13
	U Ophiuchi	15

CORRIGENDUM.

No. 367, p. 59, col. 2, CHANDLER's Elements, *for* T = 1896 Jan. 13, *put* 1896 Jan. 31.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed March 9.*

THE

ASTRONOMICAL JOURNAL.

No. 369.

VOL. XVI. **BOSTON, 1896 MARCH 21.** **NO. 9**

ON THE VARIATION OF PERSONAL EQUATION WITH THE MAGNITUDE OF THE STAR OBSERVED,

By SIMON NEWCOMB.

In preparing a new, though necessarily provisional, fundamental catalogue of star-positions, I have had to investigate the error in the observed right-ascensions of stars depending upon their magnitude. The conclusions reached are such that it seems advisable to publish a brief summary without delay, awaiting the final appearance of the work for a more complete discussion of details.

The method of investigation has been to assume that, after the differences in the observed right-ascensions are corrected for systematic error, they may be represented in the form

$$\alpha' - \alpha = x + my$$

where α and α' are the right-ascensions of a star found by the two observers, or given in the catalogues compared; and m is its magnitude. The value of y is then found by a least-square solution of the equations. Quite likely the difference should include the second or higher powers of m, as well as the first; but it is impossible to make any determination of the coefficients of these powers.

The determination of y in this way would offer no difficulty if all the results depended on a single system of adopted right-ascensions, unaffected by periodic errors varying from one part of the circle of right-ascension to another. Unfortunately this is not the case; and in consequence it is not possible wholly to separate the differences in question from those depending on errors of the assumed right-ascensions varying with the hours of right-ascension.

The error being a purely personal one, it would be desirable to separate the work of every individual observer from that of all others. This is not generally possible. I have therefore compared catalogues which depend individually upon the work of a number of observers, as well as those which depend upon the work of a single observer.

The symbols used for the absolute values of y in the case of different catalogues are as follows. Accents are used to designate observations registered on the chronograph.

P	The Pulkowa observers of 1845.
P'	The Pulkowa observers of 1865.
G	The Greenwich observers of 1845–1853.
G'	The Greenwich observers of 1854–1886.
C'	The Cape observers of 1879–1886.
B'	Becker, observer at Berlin.
K'	Küstner, observer at Berlin.
R	Romberg, observer at Berlin and Pulkowa.
A'	Boss, observer at Albany.
W'_1	The Washington observers with the transit-instrument, 1862–1865.
W'_2	Washington observers with transit-circle, 1866–1868.
H	The Paris observers, from 1860–1880.

The work of these various observers or classes is embodied in the well-known catalogues containing it, which have been used as the basis of comparison. By comparing catalogues by pairs the following system of relative values of y has been deduced:

Observers		y	Weight	$10^4y'$	10^4r
$C' - G'$	=	$+0^{s}.0013$	2.2	+ 31	−18
$C' - H$	=	+ .0051	1.7	+ 43	+ 8
$C' - R$	=	− .0001	3.0	− 4	+ 3
$R - P'_2$	=	+ .0001	4.0	− 2	+ 3
$B' - H$	=	− .0106	1.0	−106	0
$A' - H$	=	+ .0018	1.0	+ 51	−33
$P' - P$	=	+ .0059	6.0	+ 57	+ 2
$W'_1 - H$	=	− .0027	1.7	− 27	0
$W'_2 - H$	=	+ .0016	1.7	+ 16	0
$G' - H$	=	+ .0017	6.0	+ 12	+ 5
$K' - A'$	=	− .0117	1.4	− 94	−23
$K' - G'$	=	− .0007	1.0	− 55	+48
$K' - C'$	=	− .0099	1.4	− 85	−14
$G - P$	=	− .0008	1.0	+ 7	−15
$G' - P'$	=	− .0039	1.7	− 37	− 2
$G' - G$	=	−0.0002	1.0	+ 13	−15

After each equation is given the weight assigned to it: y' is the value of y as computed from a least-square adjustment of the several quantities, using these weights; and r is the residual difference between y and y'.

The symbol H, Paris, representing the authority with which the greatest number of comparisons are made, I have in the solution first referred all the values to it. The results of the relative solution are these, expressed in units of 0ˢ.0001.

$$\begin{array}{lcl|lcl} E - H &=& +48 & C - H &=& +43 \\ P' - H &=& +19 & A' - H &=& +51 \\ P - H &=& -8 & B' - H &=& -106 \\ K' - H &=& -43 & W'_1 - H &=& -27 \\ G' - H &=& +12 & W'_2 - H &=& +16 \\ G - H &=& -1 & & & \end{array}$$

These relative values give no indication of the absolute amount of the error. This can be determined only by special observers making the determinations for themselves. Among the observers compared, I am acquainted with four determinations. These have been made by GILL, KÜSTNER, BOSS and BECKER. The following are the four absolute determinations, and the resulting values of H found by referring each of them to the Paris observers.

$$\begin{array}{lcl@{\qquad}lcl} A' &=& +0\overset{s}{.}0140 & H &=& +0\overset{s}{.}0089 \\ B' &=& +\ .0070 & & & +\ .0176 \\ C &=& +\ .0108 & & & +\ .0065 \\ K' &=& +0.0029 & & & +0.0072 \end{array}$$

The result in BECKER's case shows an anomaly which I am quite unable to account for. The reduction both of BOSS and BECKER to Paris was made by comparing the right-ascensions for all the stars given in the Paris Catalogue Général for 1875, which were also found in the A.G. Zones of BOSS at Albany and BECKER at Berlin. The results are as follows. $\Delta\alpha$ is the mean excess of the R.A. of the respective zones over that of the Paris Catalogue, after correction for equinox and systematic error depending on the R.A.

	Albany		Berlin	
Mag.	No. Stars	$\Delta\alpha$	No. Stars	$\Delta\alpha$
		s		s
8.6	325	+0.013	436	−0.045
7.5	193	+ .003	220	− .041
6.5	71	− .013	87	− .040
5.5	9	+ .036	32	− .038
4.5	5	+0.024	17	−0.018

The fact is, that, notwithstanding the large personal error found by BECKER, in consequence of which the right-ascensions of his faint stars are too great, the R.A.s of those stars given in his catalogue are, when reduced for equinox, smaller by 0ˢ.045 than those observed at Paris. A natural inference would be that BECKER had already applied the correction in his catalogue. But it is expressly stated in the Introduction that the correction has not been applied. The anomaly, therefore, seems to admit of no explanation at present. Rejecting the anomalous result, the mean of the other three gives

$$H = +0^s.0075$$

This gives the following absolute values of y, in which those pertaining to eye-and-ear observations are placed in one column, and those depending on the chronograph are in another.

Eye-and-Ear		Chronograph	
	s		s
E =	+0.0123	P' =	+0.0121
P =	+ .0067	K' =	+ .0032
G =	+ .0071	G' =	+ .0087
C =	+ .0118	A' =	+ .0126
H =	+0.0075	W'_1 =	+ .0048
		W'_2 =	+0.0091
Mean	+0.0091	Mean	+0.0085

The difference between the mean values of y in the two cases is evidently markedly less than its probable error. The conclusion appears to be that the error in question equally affects eye-and-ear observations and those made with the chronograph.

There will, I conceive, be no two opinions as to the immediate cause of the error. It was pointed out by GILL, more than fifteen years ago; and, with little essential modification, is the same as one pointed out by GOULD, twenty years ago, in his discussion of the transatlantic longitude. The observer is biased in his judgement, as to the moment of the image of a star crossing the transit-thread, by his previous estimate of the moment at which it is going to cross, which is based at each moment on the apparent distance between the star and the thread. This distance appears to him greater, the smaller and better defined the image of the star. Hence the bias.

It would appear that, in the case of eye-and-ear observations, this bias ought to be neutralized by a corresponding bias in estimating the position of the star at the clock beat next following the actual transit. That the neutralization does not take effect is probably due to the fact that the observer, being hurried by the necessity of immediately recording his observation, has not the leisure to make the same careful estimate that he has when the star is approaching the thread.

In the case of chronographic observations there are two methods of observing. In method A, which I believe to be the most common, the observer anticipates the passage of the star, so as to have his signal completed at the exact moment of crossing, much as if he were shooting at a bird. Here we have good reason for the bias. In the other method, which I shall call B, the observer waits until he actually sees the star on the thread, and then commences the nisus which terminates in the signal.

In using method A, when an astronomical observer, it was frequently the custom of the writer to make a modification which might possibly result in the annulment of the error. At each transit over a thread, it was noticed whether the click of the key occurred too early or too late. If it occurred too late, the next click was made earlier, and *vice versa.* It must be added, however, that this system of compensation seemed to be practically applicable only in the daytime, or early evening, with fairly well-defined images, and when the observer's nervous system was not fatigued. As the night advanced, there appeared to be no definite moment at which the star was seen as actually bisected by the thread. The subjective phenomenon was that, as the star approached the thread, it suddenly jumped across it, as if evading the shot of the key.

As to method *B*, I must express my lack of confidence in its giving results which shall be free from the error in question. It seems to me doubtful whether the observer can avoid being influenced by his previous estimates, as he sees the star approaching the thread.

I have reached the conclusion that, in the absence of a more general system of determining this error, and on account of the uniformity in its algebraic sign, as well as its equality in the two methods of observing, it is better at present to ignore it in all star-catalogues, fundamental or otherwise, leaving each authority to apply the correction as he shall find it necessary.

The preceding conclusions have so important a bearing upon determinations of the constant of aberration, made by observations with the prime vertical, that I venture to quote the following passage from my discussion of the Constants of Astronomy, page 136, which was published one year ago.

> "Many of the Pulkowa observations are necessarily made in the morning or evening twilight. In the case of an evening observation the star will therefor be much fainter on account of daylight when it transits over the east vertical, than it will when it transits over the west vertical, one or two hours later. In the case of morning observations the reverse will be true. It is easy to see that if, in consequence of this difference of aspect, the observer notes the passage of the faint image too late, the effect will be to make the constant of aberration too large. The existence of this form of personal equation, when transits are recorded on the chronograph, is so well known that, had Nyrén's observations been made in this way, I should not have hesitated to ascribe the large values of his aberration constant to this cause. Although it has never been shown that any such personal equation exists when observations are made by eye and ear, as Nyrén's were, yet when we consider that we are dealing with quantities amounting only to one or two hundredths of a second of arc, and that a personal equation of this kind, undiscoverable by ordinary investigation, might affect the result by this minute amount, we cannot but have at least a suspicion that his values may be slightly too large from this cause."

Evidently this statement should now be modified, or rather, the conjectural conclusion is strengthened.

SOLAR PROMINENCES OBSERVED AT BOSTON UNIVERSITY OBSERVATORY,

By J. B. COIT.

The following observations are published with the hope that they may prove of value in supplying lacunae occurring in more extended series, or may be of interest when compared with results obtained by photography.

The spectroscope used is by Brashear, with a 14438 line Rowland grating, and is attached to a 7-in. refractor.

The measures were always made in *C* of the second spectrum, although the prominences were often viewed in higher spectra, and in other lines.

As a rule, one circuit of the Sun's limb was made with a tangential slit. The values of P are reckoned from the apparent north point through the east. Values of position-angle or altitude written with a subscript *e* were estimated. The definition is recorded by the letters *p*, *f*, *g*, *e*, indicating respectively poor, fair, good, excellent. The number of degrees a prominence extended upon the Sun's limb was determined, in the cases given, by estimating the fractional part of the slit filled by the prominence, hence the values are only roughly approximate.

1895 Washington M.T.				P	Alt.	Def.	Remarks
	d	h	m	°	″		
May	6	23	35	225	60.9	*g*	Narrow flame. Not found 32^m later.
	19	22	51	29	49.9	*g*	Spreading top. On each side of 29° a prominence with altitude $= 20''_e$. Others at 220°, 275°, 302°.
	23	0		206	91.5	*g*	The base was triform, altitude $= 25''$. Above this, and but slightly attached, an extended cloud, soon seen to be breaking up rapidly. At $3^h\ 17^m$ the base was composed of mere needles, while of the cloud there remained but a line, radial to the Sun, extending from $34''$ to $95''$.
		2	7	255	20.3	*g*	
			15	290	6.6		
			17	300	60.7	*g*	Base of delicate lace-work. Covered 10° of limb.
			32	20	6_e		
			42	100	52.5	*g*	
		3	2	115	76.3		Three small flames between this and 100°.
	24	21	52	105	30.4		
		22	7	117	103.0	*e*	Narrow stem $37''$, supporting a broad cloud with pendant streamers, and terminating in a mass of parallel shreds.

1895 Washington M.T.			P	Alt.	Def.	Remarks
d	h	m	°	″		
May 24	22	32	273	11.9		
		38	284	20,	*p*	Several small flames.
27	21	59	38	30	*p*	
	22	1	56	17.4	*p*	
		13	68	32.3	*g*	At 63°, and 71°, are narrow, well-defined stems, with thin, fan-like tops, arched over and uniting with top of 68°.
		18	114	19.1		
		30	227	11.8		
28	21	35	51	40.1	*g*	Central one of five slender stems, with diffuse tops all bent inward, and uniting at center of group.
		41	62	19.7		
		49	71	33.0	*g*	A diffuse bank, extending 4° on limb, top showing drift to the north.
	22	14	226	24.0		
30	2	36	34	95.2	*f*	Two clouds detached from Sun. Inner limit 66″.3.
		42	49	61.9	*f*	Bright. Broad top. At 3h 56m dissolving and floating to the north.
		56	99	6.9		
	3	22	280	5,		
		30	272	6,		
	4	0	59	28.8	*f*	Spike. Not seen at 2h 55m.
31	22	42	58	11.8	*g*	Single spike.
		47	89	20.8 69.5	*e*	Narrow, detached cloud lying radial to Sun. At 22h 57m was attached to Sun. At 23h 36m the cloud was gone, and three delicate parallel shreds lay radial to the Sun near the limb.
	23	20	246	63.5	*e*	Diffuse cloud attached to Sun by slender stem.
		26	268	20.8	*p*	
June 2	21	46	15	84.3	*g*	Stemmed. Covers 4° of limb. At 22h 32m alt. = 101″. A stem now connects each side of cloud with Sun.
		57	105	33.5	*f*	Not found at 23h.
	22	6	225	10,	*f*	An arch.
		14	269	22.2		
		18	286	10		
		25	24	22.5	*g*	Inclined to north.
		16	62			Minute flame, inclined to north.
		52	114	32.9	*p*	
6	1	59	23	37.4	*f*	Single flame.
	2	5	42	50.9	*p*	Spiked flames.
		15	94	20.7	*g*	Work stopped by clouds.
	22	2	23	12,		
		11	42	74	*p*	Covered 10° of limb. Spiked along the summit: 3h 45m later but little change. Seeing excellent.
		22	219	50.5	*p*	Cloud with narrow stem.
		31	274	34.5	*p*	Irregular form covering 10° on limb; 3h 45m later much reduced, with seeing excellent.
7	21	42	44	92.2	*g*	Inclined to north. Base 5° wide. At 22h 40m more in shreds.
		49	74			Small flame.
		52	85	31.4	*p*	Curved to north.
	22	32	224	19.2	*p*	
9	21	28	40	26.6	*p*	
		33	70	6,	*g*	Two small flames curving inward.
	22	5	237	23.2	*g*	Others smaller, estimated at 227°, 232°, 240°.
		12	266	27.5	*g*	Very narrow.
		20	274	13.8		5° on limb.
		32	283	36.1	*g*	Narrow, with spreading top.
		40	288	32.8	*f*	
		43	309	10,	*f*	
11	1	45	8		*g*	Minute points.
		50	55	10,	*g*	5° on limb.
		54	75	16.0	*g*	
		57	104			Minute points.
	2	0	130	10,		Pointed flame.
		10	215	14.2		Pointed flame.

1895 Washington M.T.			P	Alt.	Def.	Remarks
d	h	m	°	″		
June 11	2	17	243	73.7	*g*	At $3^h\ 19^m$ the altitude = 289″; Very rapid changes. See *A.J.* 350 for detailed account.
	3	35	274	48.2	*g*	
			270,	20,		
		40	295	43.7	*g*	Pointed flame. Two others near.
14	21	12	64	32.2	*g*	6° on limb.
		20	104	49.5	*p*	
	22	38	271	82.6	*f*	Triform base, supporting a cloud extending about 6° on either side, and returning to the Sun.
16	21	59	59		*f*	Six small flames.
	22	7	248	25.5	*f*	Bright. At $23^h\ 31^m$ a prong on *C* reaches half way to 6569.5.
		14	257	49.7	*p*	
17	21	14	76	12,	*e*	Brilliant. Apparently spouting obliquely from the limb and falling back upon it. At point where it seems to rise from the limb, *C* is displaced toward the blue. Minute spikes near. Spots and faculae near the limb.
		33	118	30.4	*e*	Detached cloud.
		40	221	31.5	*e*	Others at 215°, and 218°,.
		51	250		*g*	Several small spikes.
		54	263			Small.
19	22	12	17	33	*f*	3° on limb.
		15	53	24	*f*	6° on limb. Top drifting toward south.
		18	64	55.6	*f*	4° on limb. Triform base. Top drifting toward south.
		27	210		*f*	Numerous small spikes.
		30	242	41.3	*f*	Top drifting toward north.
		39	272	35.8	*f*	8° on limb. Top drifting toward north.
20	1	29	44	21.8	*p*	
		37	114		*p*	Minute arch.
		44	212	16.8	*p*	
		49	242	31.6	*p*	10° on limb.

OBSERVATIONS OF COMET *b* 1895 (*FAYE*),

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY,

By W. W. CAMPBELL.

1895 Mt. Hamilton M.T.	✶	No. Comp.	☄ − ✶		☄'s apparent		log *p*Δ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Oct. 16 8 41 25	1	*p* 8, *s* 8	−0 7.91	−1 6.8	21 10 50.93	−4 16 47.4	9.167	0.766
23 10 6 40	2	15, 8	−1 51.87	−0 43.9	21 14 46.02	−4 53 56.0	9.522	0.760
24 10 46 7	3	*p* 4, *s* 6	−0 9.76	+1 27.6	21 15 27.49	−4 58 38.9	9.592	0.753
Nov. 6 6 52 24	1	*p* 6, *s* 10	+0 0.18	+0 21.2	21 26 41.90	−5 42 31.6	8.792	0.778
7 6 45 19	5	*p* 6, *s* 8	−0 0.90	−0 50.5	21 27 45.35	−5 44 44.0	8.732	0.778
8 6 38 20	6	*p* 8, *s* 8	−0 5.00	−0 46.8	21 28 50.44	−5 46 45.6	8.643	0.779

Mean Places for 1895.0 of Comparison-Stars.

✶	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 10 55.55	+3.29	−4 15 53.7	+13.1	Schjellerup 8587
2	21 16 34.65	+3.24	−4 53 25.5	+13.4	Schjellerup 8641
3	21 15 34.02	+3.23	−5 0 19.7	+13.2	16 *Aquarii*
4	21 26 38.55	+3.12	−5 43 5.4	+13.3	12^M ±, connected with Schj. 8770
	38.69	+3.12	7.6	+13.3	12^M ±, connected with Munich II, 11776
5	21 27 43.09	+3.12	−5 14 6.3	+13.4	13^M ±, connected with Schj. 8770
	43.22	+3.12	8.2	+13.4	13^M ±, connected with Munich II, 11776
6	21 28 52.27	+3.12	−5 16 11.6	+13.4	14^M ±, connected with Schj. 8770
	52.43	+3.12	13.4	+13.4	14^M ±, connected with Munich II, 11776

NOTES.

The catalogue-intervals Mun. 11776 − Schj. 8770 are: $\Delta\alpha = -2^m\ 0^s.73$; $\Delta\delta = -0'\ 40''.8$.
My observed intervals Mun. 11776 − Schj. 8770 are: $\Delta\alpha = -2^m\ 0^s.89$; $\Delta\delta = -0'\ 39''.1$.

In fixing the positions of stars 4, 5 and 6, I have given weight 2 to the Schjellerup position, and weight 1 to the Munich position.

The comet was just at my limit of vision in the 12-inch telescope. In the 36-inch telescope it was a very easy object to measure. It was ill-defined, about 20″ in diameter, with an inconspicuous (not stellar) nucleus.

p and *s* indicate measures of position-angle and distance, respectively.

OBSERVATIONS OF COMET a 1895 (SWIFT).

MADE AT LICK OBSERVATORY,

BY W. W. CAMPBELL.

1895 Mt. Hamilton M.T.		*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 10	9 27 26	1	15	+0 22.78	. . .	1 25 57.33	. . .	n9.481	. .
	9 48 19	1	13	. . .	−2 20.2	. . .	+3 58 14.5	. .	0.692
11	9 45 12	1	20, 11	+0 30.86	−5 53.1	1 26 5.42	3 51 11.7	n9.430	0.693
12	11 11 50	2	16, 10	−0 55.86	+8 11.8	1 26 12.84	3 51 15.5	n8.991	0.688
13	11 10 12	2	19, 8	−0 49.41	+4 58.4	1 26 19.30	3 48 2.2	n8.973	0.688
15	9 41 22	2	5	. . .	−0 11.1	. . .	3 42 19.7	. .	0.691
	10 19 12	2	d 8	−0 37.79	. . .	1 26 30.93	. . .	n9.250	. .
16	11 57 35	3	p 6, s 8	−0 0.23	−0 18.2	1 26 36.68	3 39 32.3	8.417	0.688
22	10 12 28	4	p 8, s 6	−0 7.51	−4 46.9	1 27 11.38	3 28 32.3	n9.143	0.692
23	11 39 7	4	p 6, s 6	−0 0.82	−5 51.3	1 27 18.08	3 27 27.9	8.643	0.690
24	14 49 5	5	17, 6	+2 22.68	+0 22.0	1 27 25.97	3 26 33.5	9.580	0.707
25	12 14 6	5	16, 8	+2 30.32	−0 8.5	1 27 33.61	3 26 2.9	9.279	0.691
Nov. 6	7 51 26	6	15, 7	+1 24.46	+0 14.3	1 30 6.27	3 36 35.2	n9.459	0.697
	8 31 41	7	p 4, s 4	−0 0.73	−1 7.2	1 30 6.33	3 36 38.8	n9.350	0.694
7	8 23 10	8	p 6, s 8	+0 4.57	−0 24.6	1 30 25.18	3 38 54.6	n9.361	0.694
8	8 43 54	9	p 6, s 11	+0 6.30	+0 25.0	1 30 45.35	3 41 25.0	n9.274	0.691
13	7 42 32	10	p 6, s 12	−0 13.81	+0 1.1	1 32 40.36	3 56 41.2	n9.427	0.692
	8 49 58	11	10, 4	−3 15.74	−1 26.6	1 32 41.68	3 56 51.6	n9.155	0.688
17	7 48 10	12	p 6, s 6	−0 11.93	+4 2.9	1 34 33.54	4 12 22.3	n9.367	0.688
	8 22 5	13	8, 2	−1 58.56	+3 30.7	1 34 34.43	4 12 27.8	n9.233	0.686
22	11 38 11	14	16, 10	−0 21.06	+2 27.5	1 37 26.85	4 36 31.0	9.400	0.685
24	12 59 17	15	15, 8	+0 56.81	−0 53.2	1 38 44.12	4 47 15.7	9.582	0.697
Dec. 6	7 0 22	16	14, 8	+2 11.49	−2 45.6	1 47 37.09	5 58 23.7	n9.316	0.667
	8 6 0	17	22, 8	−2 13.25	+2 54.4	1 47 39.41	5 58 41.4	n8.903	0.661
7	6 27 54	18	12, 8	+1 32.02	+2 29.8	1 48 27.75	6 1 53.4	n9.405	0.671
11	8 37 7	19	p 8, s 10	+0 7.60	−0 8.9	1 52 7.95	6 33 2.5	8.230	0.653
12	7 27 46	21	p 10, s 10	−0 3.67	+1 24.3	1 53 1.57	6 39 48.4	n9.083	0.654
13	6 53 40	23	p 10, s 10	+0 9.00	+1 3.2	1 53 57.50	+6 46 44.8	n9.258	0.657

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 25 30.62	+3.93	+4 0 7.5	+27.2	Boss, A.G. Albany Catal. 116
2	1 27 4.75	+3.96	+3 42 36.4	+27.4	Boss, A.G. Albany Catal. 423
3	1 26 32.94	+3.97	+3 39 23.2	+27.3	12^{M} ±, connected with *2
4	1 27 11.87	+4.02	+3 32 51 9	+27.3	Boss, A.G. Albany Catal. 124
5	1 24 59.25	+4.04	+3 25 14.2	+27.3	Boss. A.G. Albany Catal. 409
6	1 28 37.73	+4.08	+3 35 23.9	+27.0	Boss. A.G. Albany Catal. 137
7	1 30 2.98	+4.08	+3 37 19.0	+27.0	13^{M} ±, connected with *6
8	1 30 16.52	+4.09	+3 38 52.2	+27.0	14^{M} ±, connected with *6
9	1 30 34.96	+4.09	+3 40 33.0	+27.0	11^{M} ±, connected with *2
10	1 32 50.08	+4.09	+3 56 13.3	+26.8	14^{M} ±. connected with *11
11	1 35 53.32	+4.10	+3 57 51.4	+26.8	Boss, A.G. Albany Catal. 473
12	1 34 41.37	+4.10	+4 7 52.8	+26.6	13^{M} ±, connected with *13
13	1 36 28.89	+4.10	+4 8 30.5	+26.6	Boss. A.G. Albany Catal. 480
14	1 37 43.79	+4.12	+4 33 36.9	+26.6	Tucker, meridian circle. [DM. 4°300]
15	1 37 43.50	+4.11	+4 47 42.4	+26.5	Boss. A.G. Albany Catal. 489
16	1 45 21.48	+4.12	+6 0 13.1	+26.2	Paris 2296
17	1 49 48.52	+4.14	+5 55 21.0	+26.0	⅓ (Schj. 561 + Grant 419 + Paris 2382)
18	1 46 51.61	+4.12	+6 1 57.5	+26.1	Tucker. meridian circle. [DM. 5°255]
19	1 54 56.24	+4.11	+6 32 45.6	+25.8	14^{M} ±. connected with *20
20	1 48 59.67	+4.10	+6 32 47.7	+25.9	Tucker. meridian circle, [DM. 6°298]
21	1 53 1.13	+4.11	+6 37 58.4	+25.7	13^{M} ±. connected with *22
22	1 54 37.80	+4.10	+6 34 38.8	+25.7	Tucker. meridian circle. [DM. 6°304]
23	1 53 41.39	+4.11	+6 45 15.9	+25.7	15^{M} ±. connected with *24
24	1 49 48.31	+4.09	+6 45 20.0	+25.8	Tucker. meridian circle. [DM. 6°300]

NOTES.

In order that all the observations should depend upon well-determined star-places, Prof. TUCKER kindly observed five stars, numbers 14, 18, 20, 22 and 24, with the meridian circle.

d indicates that the $\Delta\alpha$ was measured directly with the micrometer.

p and *s* indicate measures of position-angle and distance, respectively.

If the residual in declination for the first observation (October 10) proves to be large, that declination should be rejected. The divided micrometer-head was found to be loose on the screw, and shifted, unless handled with the utmost delicacy. The revolution-counter was loose and entirely misleading, and the whole number of revolutions was determined from star transits. Observations on subsequent nights were not affected by such uncertainties.

The comet passed beyond the power of the 12-inch telescope late in November. All the observations with the 36-inch equatorial were easy, except that of Dec. 11, on which occasion the sky was hazy.

Twelve or fifteen observations of the comet have been secured by Professor Hussey and myself in January and February. They will be published soon.

In the progress of these observations, as well as from my experience in observing faint objects at Ann Arbor in 1888–91, I have been convinced of a tendency on my part to estimate the transits of very faint comets over a bright thread too late, thereby increasing all right-ascensions obtained in that manner. The principal cause of the tendency is probably the following: When the faint object, several seconds of arc in diameter, approaches and touches the illuminated thread, its preceding edge melts away from view, by contact, and the center of the object appears nearer the following edge than it really is; thus the time of transit is estimated too great. This reasoning does not apply when the object is sufficiently bright to be seen clearly immediately after crossing the thread. Likewise, if the right-ascension intervals have been measured directly with the micrometer, or if the position-angle and distance have been observed, the cause referred to above does not exist. On November 6, 13 and 17, observations were obtained both by transits and by position-angles and distances. From the known rate of the comet's motion I have compared the results obtained in the two ways, and have found that the right-ascensions determined by transits are about $0^s.25$ greater than those determined by measures of position-angles and distances. Throughout the whole series of observations, made about equally in the two ways, I should expect the same systematic difference, $0^s.25$, to exist.

NOTATION OF RECENTLY DISCOVERED VARIABLES,

BY S. C. CHANDLER.

The following list, which brings the definitive notation up to date, includes, for convenience of those interested, the eleven stars for which letters were assigned in *A.J.* 358, p. 184.

The "Second Catalogue" (*A.J.* 300), the "Revised Supplement" (*A.J.* 347), and the present list comprise together a complete list of known variables; the total number being 378.

No.	Star	1900.0		1900 Annual Variation		1855.0		Redness	Magnitude	
		R. A.	Decl.			R. A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
146	T Sculptoris	0 24 17	−38 27.7	+2.96	+0.33	0 22 3	−38 42.6	–	8.6	10.0
419	U Andromedae	1 9 47	+40 11.2	3.41	0.32	1 7 14	+39 56.0	6	8.9	<13
659	X Cassiopeae	1 49 46	+58 45.9	4.09	0.30	1 46 42	+58 32.5	6	9.3	12
1166	X Ceti	3 14 20	− 1 26.0	3.05	0.22	3 12 3	− 1 36.0	–	9.3	<12.5
1386	T Eridani	3 50 57	−24 19.5	2.56	0.18	3 49 2	−24 27.6	–	7.2	11.0
1800	W Orionis	5 0 14	+ 1 2.4	3.10	+0.09	4 57 55	+ 0 58.5	–	6	7
2445	W Monocerotis	6 47 30	− 7 1.6	2.91	−0.07	6 45 19	− 6 58.6	6	8.8	<10
2690	X Puppis	7 28 27	−20 41.7	2.60	0.13	7 26 30	−20 36.1	–	8	9.6
2778	W Puppis	7 43 4	−41 57.1	2.99	0.14	7 40 49	−41 50.6	–	9.5	12.0
3264	W Cancri	9 4 0	+25 39.	3.52	0.24	9 1 21	+25 50.	–	9.6	<13
3417	U Velorum	9 29 28	−45 4.3	2.25	0.26	9 27 46	−44 52.4	–	8.1	8.5
3467	R Sextantis	9 37 46	− 7 38.7	2.97	0.27	9 35 33	− 7 26.5	–	9.7	10.6
3983	RS Carinae	11 3 54	−61 23.6	2.48	0.32	11 2 3	−61 9.0	–	8	11
4225	X Centauri	11 44 12	−41 11.9	2.99	0.33	11 41 57	−40 56.9	–	7.8	12.4
4260	W Centauri	11 50 2	−58 41.8	2.98	0.33	11 47 49	−58 26.8	–	8.6	13.0
4415	T Crucis	12 15 54	−61 43.6	3.24	0.33	12 13 28	−61 28.6	–	6.8	7.6
4885	Z Centauri	13 34 17	−31 7.6	3.39	0.31	13 31 44	−30 53.8	–	7.2	<11
5134	T Lupi	14 15 43	−49 23.5	3.94	0.28	14 12 46	−49 11.0	–	9.2	11.2
5191	Y Centauri	14 25 5	−29 39.1	3.52	0.27	14 22 27	−29 26.9	–	7.7	8.8
5192	V Centauri	14 25 23	−56 26.7	4.27	0.27	14 22 12	−56 14.5	–	6.7	7.6
5405	RT Librae	15 0 47	−18 20.8	3.39	0.24	14 58 15	−18 10.1	–	8.5	11.7<
5566	RU Librae	15 27 41	−14 59.4	3.35	0.21	15 25 10	−14 50.0	–	8.5	<12
5601	S Ursae minoris	15 33 26	+78 58.4	2.46	0.20	15 35 18	+79 7.3	7	8.4	11.5
6071	RV Scorpii	16 51 47	−33 27.2	3.92	0.10	16 48 51	−33 22.7	6	6.8	7.6
6170	RW Scorpii	17 8 18	−33 19.	3.93	0.07	17 5 21	−33 15.	–	9.4	14.1
6225	RS Herculis	17 17 31	+23 1.1	2.51	−0.06	17 15 38	+23 3.9	–	8.0	11
6871	V Lyrae	19 5 9	+29 30.0	2.35	+0.09	19 3 24	+29 25.8	–	9.1	<12
7155	RR Aquilae	19 52 24	− 2 11.	3.12	0.16	19 50 6	− 2 18.	6	8.4	<12
7162	RS Aquilae	19 53 42	− 8 10.	+3.24	+0.16	19 51 16	− 8 17.	–	10.0	<12.4

No.	Star	1900.0 R.A.	1900.0 Decl.	1900 Annual Variation		1855.0 R.A.	1855.0 Decl.	Redness	Magnitude Mag.	Magnitude Min.
		h m s	° ′	s	′	h m s	° ′			
7399	W Delphini	20 33 7	+17 55.9	+2.73	+0.21	20 31 4	+17 46.6		9.5	<12
7435	Y Aquarii	20 39 9	− 5 12.0	3.17	0.21	20 36 46	− 5 21.6	-	8.8	<13
7590	Z Capricorni	21 5 3	−16 55.2	3.35	0.21	21 2 32	−16 46.0	-	9.0	11.5
7896	V Pegasi	21 56 2	+ 5 38.4	3.00	0.28	21 53 47	+ 5 25.6	-	8.2	<13
8369	W Pegasi	23 14 46	+25 43.5	2.95	0.33	23 12 34	+25 29.1		8.1	10
8598	U Pegasi	23 52 53	+15 23.9	+3.06	+0.33	23 50 35	+15 8.9	0	8.9	9.7

OBSERVATIONS OF COMET *a* 1896,

MADE AT THE VASSAR COLLEGE OBSERVATORY WITH 12-INCH EQUATORIAL,

BY PROF. MARY W. WHITNEY AND CAROLINE E. FURNESS.

1896 Greenwich M.T.		✱	No. Comp.	☄ − ✱ Δα	☄ − ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ	Obs.
	h m s			m s	′ ″	h m s	° ′ ″			
March 3	16 9 56	1	8	+0 35.26	−1 45.1	1 11 48.88	+51 46 12.2	9.717	0.856	W
4	12 57 34	2	7	+0 6.86	+6 38.1	1 28 24.68	+51 44 7.3	9.848	0.458	F
	15 14 51	3	6	+0 59.83	+5 19.3	1 30 6.34	+51 43 27.9	9.808	0.769	W
5	13 55 12	4	8	+1 57.10	+6 7.5	1 46 13.67	+51 31 36.0	9.850	0.589	F
9	14 23 37	5	8	+0 51.86	−1 55.4	2 37 21.13	+49 54 53.4	9.836	0.586	W
12	14 26 46	6	7	+2 41.60	−7 37.3	3 2 42.67	+48 30 51.7	9.823	0.572	W
13	16 26 44	7	8	+0 45.50	+7 57.0	3 10 6.80	+48 1 59.0	9.767	0.792	W

Mean Places for 1896.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 11 14.81	−1.19	+51 17 44.9	+12.4	Rogers, Cambridge Ast. Ges. Catal. 582
2	1 28 18.82	−1.00	+51 37 15.4	+13.8	" " " " " 703
3	1 29 7.51	−1.00	+51 37 54.7	+13.9	" " " " " 709
4	1 44 17.42	−0.85	+51 25 13.8	+14.7	½(Rogers.Camb..Ast.Ges.Catal.846+Cincin.248)
5	2 36 29.59	−0.32	+49 56 31.6	+16.9	Deichmuller. Bonn A.G Catal. 2312
6	3 0 1.18	−0.11	+48 38 11.8	+17.2	" " " " 2619
7	3 9 21.33	−0.03	+17 53 44.8	+17.2	" " " " 2730

COMET *a* 1896.

On the evening of March 10 a communication was received from Prof. W. J. HUSSEY of the Lick Observatory, containing new elements and ephemeris for this comet.

By some unexplained mishap, the paper has gone astray, — this accident being the first of the sort since the reëstablishment of the Journal. A duplicate copy has been requested by telegraph.

Meanwhile, in order that those American astronomers, who may be disposed to observe the comet, may not be without an ephemeris, that published on p. 56 is here continued.

EPHEMERIS FOR GREENWICH MIDNIGHT.

1896		App. α	App. δ	log Δ	Br.
		h m s	° ′		
March	23.5	3 53 36	+44 29.1	0.0935	0.05
	25.5	3 59 22	43 56.6	.1179	.05
	27.5	4 1 33	43 27.2	.1407	.04
	29.5	9 17	43 0.6	.1622	.03
	31.5	13 37	42 36.0	.1826	.03
April	2.5	17 39	42 13.7	.2018	.03
	4.5	4 21 22	+41 53.3	0.2200	0.02

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed March 19.*

THE
ASTRONOMICAL JOURNAL.
No. 370.

VOL. XVI. BOSTON, 1896 MARCH 27. NO. 10

MICROMETRICAL OBSERVATIONS OF THE FOUR SATELLITES OF THE PLANET *URANUS*, AND MEASURES OF THE DIAMETERS OF *URANUS*,

MADE WITH THE 36-INCH REFRACTOR OF THE LICK OBSERVATORY IN 1894 AND 1895,

BY E. E. BARNARD.

During the years 1894 and 1895, while connected with the Lick Observatory, I took up the measurement of the positions of the four moons of the planet *Uranus*. This was my first opportunity to do the work with the great telescope.

In *Monthly Notices* for 1894 January, Mr. MARTH has called attention to the importance of observations of these objects.

The satellites were observed at every opportunity during the two oppositions, and the measures obtained are herewith presented. The two inner ones were usually difficult objects, even with the great telescope. Under ordinary conditions *Ariel* the closest was usually the easier of the two. *Titania* and *Oberon* were always more or less easy, though they were difficult if there was any wind to disturb the telescope.

All the measures of these satellites were referred to the center of the disc of *Uranus*, and were made by the method of double distances. In the observations for each satellite, I have given first the observed position-angle, and then the means of the measures for each set of double distances. All the times are Standard Pacific Time, which is $8^h\ 0^m$ slow of Greenwich. I have not applied any correction for refraction to any of the measures.

During these observations, I was struck with the fact that the disc of *Uranus* appeared decidedly elliptical. This was specially noticeable when one of the threads was placed across the planet in the distance-measures.

A series of settings was made during the two oppositions to determine the position-angle of this ellipticity to see if it agreed with the position of the orbital plane of the satellites. At first the observations seemed to indicate that such was the case, but the more complete measures, extending through the two years, seem to show that the apparent major-axis of the disc does not agree with the planes of the satellite orbits.

I have tabulated all these measures of position-angle, and print them here. It will be seen that some of them are rather wild. It was not always easy to tell when the thread was parallel with the major-axis of the disc because of the smallness of the image. The means of the two years, however, differ by less than 4°. I thought this elongation might be an effect of instrumental flexure, or of atmospheric dispersion. To test this the hour-angle of the planet at the measures is given. There does not seem to be any definite relation between the position-angles and the hour-angle of the planet, and I am inclined to think the apparent ellipticity was real. If this is so, and the position-angles represent the true position of the equator of *Uranus*, the satellite orbits must deviate some 20° or 30° from that plane. In all the measures for these position-angles the major-axis of the disc was made perpendicular to the line between the eyes.

In 1894 I also made a series of measures of the apparent polar and equatorial diameters of *Uranus*. These clearly show the ellipticity of the disc, and indicate a large polar compression — greater even than that of *Saturn* — which would imply a rapid axial rotation.

In my measures of *Neptune* and his satellite with the same instrument, I have never been able to detect any evidence of a polar compression, though such has been carefully looked for. The present position of the orbit of the satellite of *Neptune*, however, would rather discourage the probability of detecting any compression in the planet. This same objection, however, applies in the case of *Uranus* with still greater force, because we are looking now almost perpendicular to the plane of the satellite orbits.

The absence of eccentricity in the disc of *Neptune* would, however, rather tend to show that the ellipticity in that of *Uranus* is not an instrumental effect. The lower altitude of *Uranus* — from its southern declination — may be responsible through atmospheric dispersion for the apparent elongation of the disc. *Neptune*, from its greater altitude, would not be perceptibly affected from this cause. I submit the measures, however, without any positive claim that the appearance is not in some way due to the low altitude of the planet.

Since writing the above, I have found a statement in YOUNG'S *General Astronomy*, that is very interesting in connection with my observations. In speaking of *Uranus* Professor YOUNG says:

"The disc of the planet shows a decided ellipticity about $\frac{1}{14}$ according to the Princeton observations of 1883—which agree nearly with those of SCHIAPARELLI. There are also sometimes visible upon the planet's disc certain extremely faint bands or belts, much like the belts of *Jupiter* viewed with a very small telescope. What is exceedingly singular, however, is that the trend of these belts seems to indicate a *plane of rotation not coinciding with the plane of the satellites' orbits*. Nearly all the observers who have seen them at all find that they are inclined to the satellite's orbit-plane at an angle of from 15° to 40°."

During these observations a careful series of comparisons was made of the relative light of the four satellites, separated into two groups. *Titania* and *Oberon* were repeatedly compared with each other; in the same manner *Ariel* and *Umbriel* were compared. The results show a possible variation in the light of either *Titania* or *Oberon*, or in both.

Titania and *Oberon* are ordinarily very nearly equal in brightness. The observations, however, seemed to show a variation of their relative light amounting on the whole to as much as an entire magnitude.

Following are the notes, made at the time of the position-measures, on the relative light of *Titania* and *Oberon*.

1894.

July 16. *Titania* is ¼ to ½ magnitude brighter than *Oberon*.

July 22. Possibly *Oberon* is a little brighter than *Titania*.

July 30. *Titania* and *Oberon* are equal. Possibly *Titania* is a little bit brighter than *Oberon*.

1895.

March 31. *Oberon* is ½ magnitude brighter than *Titania*.

April 14. *Oberon* is $\frac{2}{10}$ magnitude brighter than *Titania*.

April 22. *Titania* is perhaps $\frac{2}{10}$ magnitude brighter than *Oberon*. They are very nearly equal.

May 6. *Titania* is ½ magnitude brighter than *Oberon*.

May 19. *Titania* and *Oberon* are so nearly alike that it is impossible to decide which is the brighter.

June 2. *Titania* is ½ magnitude brighter than *Oberon*.

June 3. *Titania* is ½ magnitude brighter than *Oberon*.

June 16. *Titania* is ¼ magnitude brighter than *Oberon*.

June 17. *Titania* is ½ magnitude brighter than *Oberon*.

June 24. *Oberon* is ½ magnitude brighter than *Titania*.

July 7. *Titania* is brighter than *Oberon*.

July 14. *Titania* is ¼ magnitude brighter than *Oberon*.

July 21. *Oberon* is ½ magnitude brighter than *Titania*.

Aug. 11. *Titania* is about ¼ magnitude brighter than *Oberon*.

Following are the light-comparisons of *Ariel* and *Umbriel*.

1895.

May 6. *Ariel* is ½ magnitude brighter than *Umbriel*.

May 12. *Ariel* is ½ magnitude brighter than *Umbriel*.

May 19. *Ariel* is a little less bright than *Umbriel*.

June 30. *Ariel* is ½ magnitude brighter than *Umbriel*.

Aug. 12. *Ariel* is about ¼ to ½ magnitude brighter than *Umbriel*.

It will be seen that these comparisons make *Ariel* about ½ magnitude brighter than *Umbriel*, and this seems constant, except on May 19, when *Umbriel* was a little the brighter: this in all probability was due to the difficulty of seeing *Ariel*, it being more effected by the glare about the planet.

In the case of *Titania* and *Oberon* the comparisons were easily made because both these satellites are far enough away from *Uranus* not to be affected by the planet's brightness. They do not differ much in distance from *Uranus*, and the light-comparisons will not be subject to much uncertainty. That there is an apparent variation the observations I think show conclusively; whether this is real or not is another question. Just now there are not enough observations to definitely settle the question. I shall hereafter make special observations to decide this point. With the proper observations it will be easy to tell whether the variation is real, and if so, to single out the variable satellite; or, if both are variable, to determine all the peculiarities of variation.

If we keep either satellite in a constant position-angle, and compare the other with it in all position-angles, the source of variation and its peculiarities will be pointed out.

To test this with the present comparisons a tabulation according to order of the position-angles was made for the foregoing estimates of magnitudes, but the comparison of these observations does not give much information as to where the variability lies.

To determine whether their relative position in the field of view had anything to do with their variation of light, I have roughly plotted their positions at the times of observation. The result shows that it does not seem to make any special difference as to which is right or left, but there does seem to be a relation between which is uppermost in the field of view, and its brightness.

In every case where *Oberon* was uppermost *Titania* was the brighter, and in every case where *Titania* was uppermost *Oberon* was the brighter. When the two were near the same horizontal line they were equal either of the satellites being right or left.

It would appear, therefore, that the apparent variation of light is probably due to a physiological effect, and that my eye has a tendency to make the lower of two equal lights appear the brighter by about ⅓ magnitude. It would also seem from this that the two outer satellites of *Uranus*, *Titania* and *Oberon*, are as nearly equal in brightness as they can be, and that so far as these observations show, they are probably constant in their light.

As a verification of the above statement a new tabulation was made, which showed that in every one of the ten cases the satellite which was uppermost was fainter.

The observations also show that as the two neared a horizontal line they became more nearly equal in their light.

Fortunately this is a question that can be readily settled by future observations. I am, however, rather convinced that the variation of light is not real, though it seemed very certain at first that it was.

Following are the measured position-angles of the apparent ellipticity of the disc of *Uranus*.

Position-Angles of the Major-Axis of the Disc of *Uranus* in 1894–5.

		P.A.	Hour-Angle
1894	h m	°	h m
April 23	13 50	25.5	1 7 W
29	12 40	11.3	0 21 W
30	12 30	16.8	0 10 W
May 6	12 15	19.5	0 25 W
7	11 40	12.3	0 5 E
21	10 30	7.0	0 19 E
27	11 14	49.5	1 30 E
28	10 0	7.1	0 20 E
June 11	10 5	30.1	0 42 W
18	10 0	43.6	1 5 W
July 8	9 0	40.6	1 25 W
22	8 15	40.0	1 35 W
29	8 5	32.8	1 52 W
30	8 0	17.3	1 51 W
Means		25.27	0h.6 W

		P.A.	Hour-Angle
1895	h m	°	h m
Mar. 4	17 0	54.5	0 34 W
Apr. 8	15 10	32.7	1 5 W
14	13 45	35.7	0 5 W
21	13 40	12.2	0 28 W
Apr. 22	13 0	14.3	0 8 E
May 5	13 30	52.0	1 16 W
6	12 3	10.5	0 20 W
12	12 25	30.3	0 39 W
June 2	11 25	11.8	1 5 W
3	11 35	26.8	1 19 W
24	10 40	29.4	1 52 W
Means		29.1	0h.7 W

Polar and Equatorial Diameters of *Uranus*, 1894.

	Polar Obs.	Polar Δ	Equat. Obs.	Equat. Δ
	″	″	″	″
April 9	4.46	4.11	4.65	4.30
May 6	4.22	3.88	4.32	3.97
7	4.07	3.74	4.24	3.90
21	4.28	3.94	4.50	4.14
28	4.20	3.88	5.15	4.76
June 11	4.18	3.88	4.34	4.03
18	4.15	3.87	4.24	3.96
July 8	4.45	4.22	4.39	4.16
29	3.99	3.85	4.23	4.08
Means		3.930		4.150

Δ represents the observed values reduced to distance 19.18329, the mean distance of *Uranus* from the sun. These correspond to a mean diameter of 34 900 miles.

On account of the unknown position of the polar-axis of *Uranus* no correction can be applied to the polar measures for inclination.

Following are the measured position-angles (P.A.) and distances (Δ) of the four satellites. The second distance in each case being made with the threads in a reversed position to that of the first. Usually these are each the mean of three settings of the threads, while the position-angle is the mean of four settings.

I regret that it was not possible to make these observations more continuous — on a greater number of days. The orbits seem to be pretty well covered with the measures, however.

In these measures a power of 350 was mostly used, sometimes 520. For the diameters of *Uranus*, however, a power of 1000 was uniformly employed.

In these and all other observations that I have made with the 36-inch, the full aperture has always been used.

	Std. Pac. T.	P.A.	Obs.	Std. Pac. T.	Δ	Obs.	Std. Pac. T.	Δ	Obs.	Notes
				Ariel.						
1894	h m s	°		h m s	″		h m s	″		
Apr. 16	13 46 33	190.8	4	13 54 0	14.86	3	13 59 6	13.65	3	
23	12 21 25	107.6	3	13 43 43	13.18	3	13 47 18	13.00	3	
	13 37 55	116.4	4							
29	12 25 30	237.1	4	12 31 16	13.35	3	12 34 34	13.04	3	
30	11 54 57	19.6	4	12 4 50	14.41	3	12 7 50	14.70	3	
May 6	12 14 1	165.3	4	12 18 30	14.38	3	12 21 58	14.01	3	
7	11 56 42	307.7	4	12 1 58	13.05	3	12 4 40	13.21	3	
June 18	10 39 17	176.2	4	10 48 54	14.69	3	10 52 16	14.83	3	

Ariel.—Contin.

	Std. Pac. T.	P.A.	Obs.	Std. Pac. T.	Δ	Obs.	Std. Pac. T.	Δ	Obs.	Notes
1894	h m s	°		h m s	″		h m s	″		
July 1	9 2 9	215.3	4	9 20 22	13.63	3	9 24 10	13.31	3	
2	9 22 2	6.1	4	9 27 48	14.59	3	9 31 46	14.79	3	
1895										
Mar. 31	14 51 33	9.4	4	14 58 16	14.44	3	15 2 34	14.60	3	Wind shaking the telescope badly. The other satellites could not be measured.
Apr. 8	15 18 50	72.3	4	15 25 19	13.86	3	15 29 2	13.34	3	
29	12 32 3	177.6	4	12 38 14	14.34	3	12 41 56	15.17	3	
May 5	12 49 48	318.8	4	12 58 26	13.60	3	13 2 41	13.77	3	Satellite very faint.
6	12 17 31	96.0	4	12 24 10	13.28	3	12 27 20	13.08	3	
12	11 36 12	223.4	4	11 41 26	13.68	3	11 44 40	14.00	3	
19	10 45 12	147.4	4	10 51 20	14.00	3	10 54 30	14.34	3	
June 2	9 34 9	338.7	4	9 39 28	14.51	3	9 42 58	15.00	3	
3	11 0 24	132.8	4	11 6 24	13.66	3	11 9 18	13.37	3	
30	9 34 51	15.6	4	9 42 16	15.04	3	9 52 0	14.47	3	
July 1	10 1 2	262.4	4	10 4 54	15.27	3	10 7 6	14.51	3	About 13$^{\rm M}$. Pretty bright. From the brightness of this object it was probably a star.
15	9 24 15	358.7	4	9 33 15	14.83	3	9 37 40	14.79	3	
21	9 18 48	136.4	4	9 27 4	13.53	3	9 30 12	13.95	3	

Umbriel.

	Std. Pac. T.	P.A.	Obs.	Std. Pac. T.	Δ	Obs.	Std. Pac. T.	Δ	Obs.	Notes
1894	h m s			h m s	″		h m s	″		
Apr. 29	12 47 30	35.6	4	12 53 4	19.51	3	12 56 6	19.57	3	
30	11 10 21	126.6	4	11 47 18	17.63	3	11 50 8	17.72	3	
May 6	12 27 12	287.8	4	12 34 19	17.88	3	12 38 12	18.01	3	
7	12 9 29	12.5	4	12 16 18	20.61	3	12 19 0	20.28	3	
July 1	9 31 42	99.9	3							Satellite lost before distance could be measured.
2	10 5 28	189.3	3	9 52 42	19.71	3	9 56 52	19.31	3	
8	9 27 39	353.8	4	9 32 48	20.09	3	9 36 54	20.03	3	
1895										
Apr. 22	13 25 15	180.3	4	13 31 30	20.45	3	13 35 0	20.50	3	
May 12	11 50 24	115 0	1	11 56 30	18.68	4	12 0 9	18.35	1	
19	11 3 12	358.2	4	11 10 55	20.41	3	11 13 55	20.05	3	
June 9	9 42 0	15.4	4	9 47 55	19.20	3	9 52 48	20.07	3	
17	9 50 36	356.4	4	9 57 0	20.64	3	10 0 0	19.21	3	Satellite difficult
30	10 14 32	39.1	5	10 23 28	18.10	3	10 34 56	18.85	4	
July 8	9 3 15	14.9	4	9 9 25	19.65	3	9 13 42	20.63	3	
Aug. 12	8 43 21	325.9	4	8 53 3	19.54	4				Too faint and low for double distance.

Titania.

	Std. Pac. T.	P.A.	Obs.	Std. Pac. T.	Δ	Obs.	Std. Pac. T.	Δ	Obs.	Notes
1894	h m s	°		h m s	″		h m s	″		
Apr. 30	12 13 0	116.5	4	12 18 13	28.98	3	12 21 54	29.19	3	
May 7	12 33 13	38.9	4	12 37 36	31.85	3	12 41 7	31.76	3	
21	9 55 0	255.4	4	10 0 43	28.88	3	10 4 36	28.13	3	
28	9 24 18	186.2	4	9 30 8	34.14	3	9 32 52	34.58	3	
June 11	10 15 30	41.8	4	10 26 2	31.27	3	10 31 46	30.81	3	
18	10 23 11	341.4	4	10 28 28	32.35	3	10 32 6	32.12	3	The two sets of measures on this date evidently refer to the same object, though it was not so intended. I have a note to the first observation saying: "*Oberon* is 10″ north preceding it." This must have been a fixed star instead of *Oberon*.
	10 56 18	342.1	4	11 1 12	32.37	3	11 4 42	32.12	3	
24	10 44 52	218.5	4	10 49 30	30.90	3	10 52 46	30.97	3	
25	9 57 12	162.7	4	10 3 43	27.27	3	10 7 10	27.20	3	
July 1	9 53 31	157.2	4	10 2 36	32.48	4	10 5 48	31.71	3	
8	9 41 35	79.6	4	9 46 20	27.72	3	9 50 30	27.47	3	
9	9 26 19	127.7	4	9 31 28	28.79	3	9 35 26	28.23	3	
15	8 55 19	19.3	4	9 0 24	32.53	3	9 3 26	32.70	3	
16	8 55 3	47.3	1	8 59 30	29.54	3	9 2 26	30.13	3	
22	8 24 3	303.4	4	8 28 32	27.50	3	8 31 16	27.32	3	
23	9 11 23	345.8	4	9 18 6	31.97	3	9 21 40	31.72	3	
29	8 38 42	41.8	4	8 43 6	29 67	3	8 46 30	29.68	3	
30	8 19 27	267.8	4	8 24 20	26.65	3	8 27 38	26.08	3	
1895										
Apr. 1	13 43 35	332.2	4	13 49 18	33.11	3	13 52 6	32.40	3	
14	14 38 19	50.8	4	14 44 8	32.87	3	14 48 10	32.95	3	
21	12 20 12	70.7	4							Clouded here. Cleared again.
	13 29 57	74.3	1	13 34 16	30.16	3	13 38 42	29.90	3	
22	13 40 19	119.7	4	13 45 31	30.91	3	13 48 46	30.91	3	
28	14 41 48	6.9	4	14 48 13	33.86	3	14 52 8	33.73	3	

		Std. Pac. T.	P.A.	Obs.	Std. Pac. T.	Δ	Obs.	Std. Pac. T.	Δ	Obs.	Notes
								Titania. — Contin.			
1895		h m s	°		h m s	″		h m s	″		
Apr.	29	12 20 21	41.3	4	12 25 16	31.55	3	12 27 22	31.61	3	
May	5	13 11 42	296.0	4	13 16 34	30.45	3	13 19 54	30.48	3	
	6	11 50 0	335.9	4	11 55 38	32.68	3	11 58 37	33.31	3	
	13	10 21 49	258.4	4	10 26 54	29.63	3	10 29 42	30.05	3	
	19	10 32 18	151.8	4	10 37 20	32.33	3	10 40 18	32.99	3	
	20	9 48 18	186.8	4	9 52 56	34.26	3	9 55 38	33.97	3	
June	2	9 19 5	5.1	4	9 24 26	33.81	3	9 26 42	33.69	3	
	3	11 13 55	45.8	4	11 20 48	31.24	3	11 23 22	31.17	3	
	9	9 7 25	297.2	4	9 12 8	29.37	3	9 15 46	29.93	3	
	10	9 45 24	340.5	4	9 50 0	32.76	3	9 52 54	33.20	3	
	16	8 53 27	219.4	4	8 59 18	31.23	3	9 3 40	31.09	3	
	17	10 14 52	267.4	4	10 20 0	28.23	3	10 22 34	28.93	3	
	24	10 25 35	194.2	4	10 31 34	33.63	3	10 33 57	33.17	3	
	30	8 53 51	80.3	4	8 59 12	29.07	3	9 4 10	28.76	3	
July	7	10 4 36	13.0	4	10 9 2	32.85	3	10 12 10	32.86	3	
	8	9 47 54	50.8	4	9 52 48	29.91	3	9 56 28	29.83	3	
	14	9 25 6	305.8	4	9 29 24	29.10	3	9 32 46	29.13	3	
	15	9 56 43	347.0	4	10 1 38	31.92	3	10 4 26	32.93	3	
	21	8 47 48	225.4	4	8 52 36	29.86	3	8 55 48	30.17	3	
	22	9 0 12	271.1	4	9 7 48	27.78	3	9 10 34	27.99	3	
Aug.	5	8 21 21	133.6	4	8 26 38	29.25	3	8 29 42	29.37	3	
	11	8 8 45	15.9	4	8 13 0	31.75	3	8 15 40	31.74	3	
	12	8 18 26	54.9	4	8 23 16	28.98	3	8 26 0	28.86	3	
	18	7 58 21	310.9	4	8 6 10	28.71	3	8 8 40	28.56	3	
								Oberon.			
1894		h m s	°		h m s	″		h m s	″		
May	21	10 10 35	210.6	4	10 16 56	43.98	3	10 20 0	44.71	3	
	28	9 42 13	36.4	4	9 50 27	43.40	3	9 55 2	43.22	3	
June	11	10 37 13	51.9	4	10 42 24	40.71	3	10 45 46	40.28	3	
	24	10 58 5	39.6	4	11 3 11	41.92	4	11 7 16	41.28	3	
	25	10 12 30	66.4	4	10 18 38	38.76	3	10 22 20	37.96	3	
July	1	10 10 27	225.2	4	10 15 44	40.44	3	10 19 7	40.61	4	
	8	9 56 48	52.3	4	10 3 12	39.04	3	10 6 51	39.63	3	
	9	9 39 30	82.2	4	9 46 1	36.66	3	9 49 56	36.27	3	
	15	9 7 13	238.7	4	9 11 38	38.24	3	9 14 48	38.11	3	
	16	8 40 15	269.9	4	8 46 2	35.67	3	8 49 36	36.11	3	
	22	8 36 15	66.3	4	8 42 6	36.80	3	8 45 30	37.15	3	
	23	8 51 11	99.3	4	8 59 24	35.72	3	9 3 58	36.09	3	
	30	8 32 9	287.4	4	8 36 22	35.31	3	8 39 42	35.45	3	
Aug.	5	8 13 54	82.9	4	8 19 42	35.62	3	8 23 13	35.17	3	
1895 Mar.	4	17 15 50	337.5	4	17 21 40	43.81	2				Observations interrupted before finished.
Apr.	1	13 57 10	360.6	4	14 2 0	44.53	3	14 5 42	45.34	3	
	14	14 56 30	350.5	4	15 2 28	45.02	3	15 5 16	44.85	3	
	21	13 52 27	175.9	4	14 1 7	45.17	3	14 5 14	45.71	3	
	22	13 8 48	199.5	4	13 14 42	45.04	3	13 18 10	44.83	3	
	28	14 58 2	4.2	4	15 2 20	45.67	3	15 5 14	45.77	3	
May	6	11 36 54	210.6	4	11 41 6	43.44	3	11 45 8	43.90	3	
	13	10 35 51	36.3	4	10 41 4	43.59	3	10 45 12	43.92	3	
	19	11 20 49	198.9	4	11 26 0	44.83	3	11 28 54	44.96	3	
	20	9 59 55	222.2	4	10 3 56	42.58	3	10 6 40	42.13	3	
June	2	10 14 54	210.8	4							Observations interrupted here.
		11 0 30	212.3	2	11 5 47	43.37	4	11 9 8	43.45	3	
	9	9 22 54	36.6	4	9 28 2	42.63	3	9 30 42	42.27	3	
	10	9 58 0	64.8	4	10 3 52	40.32	4	10 8 31	40.19	3	"There is a small star, slightly less than the satellite, 1″–2″ n.f. Did not see it until after the first measures; the two last are of the brighter object." Qus. — Which was the satellite?
	16	9 7 42	223.3	4	9 12 18	42.26	3	9 15 16	41.98	3	
	17	10 26 27	253.3	4	10 30 4	39.27	3	10 32 40	39.42	4	
	24	10 13 48	81.8	4	10 18 0	38.70	3	10 20 57	38.90	4	
	30	9 10 5	238.4	5	9 17 34	39.75	3	9 21 24	39.69	3	

Oberon. — Contin.

1895	Std. Pac. T.	P.A.	Obs.	Std. Pac. T.	Δ	Obs.	Std. Pac. T.	Δ	Obs.	Notes
	h m s	°		h m s	″		h m s	″		
July 7	9 51 24	67.6	4	9 56 6	39.00	3	9 59 30	38.92	3	
July 8	9 26 40	97.5	4	9 32 1	38.08	3	9 41 30	38.26	3	
14	9 10 51	253.4	4	9 16 12	38.24	3	9 19 46	37.63	3	
15	9 43 10	285.9	4	9 47 26	37.92	3	9 50 42	37.47	3	
21	8 30 3	81.6	4	8 34 38	37.49	3	8 40 0	37.40	3	
22	9 15 33	113.6	4	9 20 34	38.20	3	9 23 36	38.45	3	
Aug. 5	8 38 53	129.0	4	8 43 2	39.29	3	8 45 58	39.41	3	
11	8 18 54	286.4	4	8 22 42	36.71	3	8 26 20	37.27	3	
12	8 0 11	314.8	4	8 6 20	39.97	3	8 9 56	39.06	3	

Kenwood Observatory, Chicago, Ill., 1895 *Dec.* 21.

OBSERVED MAXIMA AND MINIMA OF 8598 *U PEGASI*,

BY PAUL S. YENDELL.

Since publishing my observations of this star in Vol. XV of this Journal, p. 191, I have observed seven minima and six maxima, as follows:

Minima				wt.	Maxima				wt.
	d	h	m			d	h	m	
1895 Nov.	11	7	57	3	1895 Nov.	11	10	21	4
	16	9	8	4		16	7	18	4
	27	7	4	3		27	8	32	4
Dec.	8	8	36	4	Dec.	6	8	10	3
	14	8	10	4		14	5	50	3
	15	6	44	3		16	8	4	4
	19	9	7	4					

A minimum observed 1895 July 30, 12^h 47^m, has been accidentally omitted in the former paper.

The interval from minimum to maximum seems not to be constant; ranging, in the above observations, from 1^h 28^m to 3^h 11^m.

The large anomalies noted by CHANDLER and myself in the observed phases of the star continue to present themselves in the above phases.

Their reality is strongly indicated by the close coincidence of his observations with my own in the phases simultaneously observed by both.

An examination of the residuals thus far obtained gives no clew to the law of these anomalies, and no elements in any degree approaching finality can be arrived at until at least one more season's observations are available.

It is earnestly hoped that all observers having optical means sufficient for good determinations of the minima will exert themselves to observe as many phases as possible, so that we may have available, at the close of the next season's observations, as nearly a continuous series of observed phases as may be.

Dorchester, Mass., 1896 *February* 22.

ELEMENTS AND EPHEMERIS OF COMET *a* 1896,

BY WILLIAM J. HUSSEY.

By mistake in translating telegram of Kiel observation (Feb. 13) of Comet *r* 1895 (Perrine), a wrong position was obtained. Mr. PERRINE examined this position the next morning and discovered Comet *a* 1896.

From Mr. PERRINE's observation at the time of discovery, Feb. 15, and my observations of Feb. 20 and 25, I have computed the following elements and ephemeris.

$$T = 1896 \text{ Jan. } 31.77508 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \omega &= 358^\circ\ 21'\ 24''.7 \\ \Omega &= 208\ \ 52\ \ 26.1 \\ i &= 155\ \ 45\ \ 37.2 \end{aligned}\right\} \text{Equin. } 1896.0$$

$$\log q = 9.768844$$

For the middle place (O – C).

$$\Delta\lambda\cos\beta = +2''.0; \quad \Delta\beta = -2''.0; \quad \frac{\tan(\lambda-\odot)}{\sin\beta} = -1.066$$

Mt. Hamilton, Cal., 1896 *March* 16.

Constants for the equator:

$$x = r[9.991294] \sin(241^\circ\ 39'\ 46''.0+v)$$
$$y = r[9.858060] \sin(320\ \ 27\ \ 36.8+v)$$
$$z = r[9.857651] \sin(342\ \ 53\ \ 14.2+v)$$

EPHEMERIS FOR GREENWICH MIDNIGHT.

1896	App. α	App. δ	log Δ	Br.
	h m s	° ′		
March 22.5	3 50 16	+44 47.4	0.081	0.06
26.5	4 1 51	43 42.6	0.130	0.04
30.5	4 11 19	42 49.0	0.173	0.03
April 3.5	4 19 21	42 4.4	0.211	0.025
7.5	4 26 24	41 27.0	0.246	0.019
11.5	4 32 46	40 55.4	0.277	0.015
15.5	4 38 34	40 28.5	0.305	0.012
19.5	4 43 58	40 5.5	0.331	0.010
23.5	4 49 3	39 45.8	0.354	0.009
27.5	4 53 53	+39 29.1	0.376	0.007

Brightness Feb. 15.0 is taken as unity. The comet is following closely the ephemeris computed from the above elements.

FILAR-MICROMETER OBSERVATIONS OF COMET *a* 1895 (SWIFT),

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY ORMOND STONE.

1895 Charlottesville M.T.		*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 12	11 13 59	13	28 , 4	−0 49.79	+7 17.1	. . .	. . .	9.144	0.693
13	9 38 39	11	12 . 1	−3 18.31	−1 44.0	1 32 39.11	+3 56 34.2	n8.650	0.691
18	8 28 14	15	48 , 2	−0 26.37	+2 1.1	. . .	. . .	9.176	0.690
	8 28 14	16	48 , 2	−0 27.94	+1 5.1	. . .	. . .	9.176	0.690
Dec. 13	10 6 54	17	4 , 2	+4 5.84	+1 5.4	1 53 58.31	+6 46 50.0	9.310	0.664
	10 7 50	18	6 , 0	−0 27.59	. . .	1 53 58.17	. . .	9.390	. .
14	9 17 59	20	15 , 4	+0 24.69	−3 7.6	1 54 54.17	+6 53 49.7	8.890	0.658
16	9 40 6	21	16 , 4	−0 17.22	−2 14.9	1 56 53.13	+7 8 30.9	9.241	0.658

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
14	1 35 53.32	+4.10	+3 57 51.4	+26.8	Boss, Albany A.G. Catal. 173
17	1 49 48.38	+4.09	+6 45 18.8	+25.8	2 observations, Dr. Peter, Leipzig
18	1 54 21.64	+4.12	+6 47 ±	+25.7	Comp. with *17
19	1 53 28.81	+4.11	+7 1 16.3	+25.7	2 observations, Dr. Peter, Leipzig
20	1 54 25.36	+4.12	+6 56 31.6	+25.7	Comp. with *19
21	1 57 6.22	+4.13	+7 10 20.2	+25.6	Bessel's Zone 118

OBSERVATIONS OF COMET *a* 1896,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

1896 Cincinnati M.T.		*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
March 4	7 33 56	1	12	−0 30.69	+6 7.6	1 28 35.81	+51 44 16.2	9.853	0.303
7	9 20 19	2	10	+0 45.60	−1 3.3	2 15 17.24	+50 47 59.9	9.860	0.574
13	9 31 32	3	8	+0 40.09	−4 15.4	3 9 45.65	+48 2 55.1	9.836	0.545
16	9 29 21	4	8	−1 54.88	+3 23.5	3 26 45.02	+46 48 18.4	9.825	0.537

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 29 7.50	−1.00	+51 37 54.7	+13.9	Rogers, Cambridge A.G. Catal. 709
2	2 14 32.39	−0.75	+50 48 47.0	+16.2	Rogers, Cambridge A.G. Catal. 1096
3	3 9 5.59	−0.03	+48 6 53.3	+17.2	Deichmüller, Bonn A.G. Catal. 2726
4	3 28 39.78	+0.12	+46 44 37.9	+17.0	Deichmüller, Bonn A.G. Catal. 3023

CORRECTION TO THE EPHEMERIS OF COMET *a* 1896.

BY A. O. LEUSCHNER AND F. H. SEARES.

In no. 367 of the *Astronomical Journal*, the difference, O−C, between the Northfield, Minn., observation of Feb. 21.9885 Gr. M.T., and the ephemeris computed at the Students' Observatory, Berkeley, is given as -32^s and $+14'$. The last of the observations so far secured here with the 6-inch equatorial gives the following position for the comet (corrected for parallax and aberration): 1896 March 12.710534 Gr. M.T., $\alpha = 3^h\ 3^m\ 32^s.41$; $\delta = +48°\ 28'\ 6''.0$. This observation gives the following corrections to the ephemeris on March 12, O−C, $+13^s.7$ and $-39''$. As the ephemeris of Dr. Chandler, whose orbit is based on the Northfield observation, agrees closely with the Berkeley ephemeris, it would seem that the residuals printed in no. 367 are erroneous.

University of California, Students' Observatory, 1896 *March* 15.

OBSERVATIONS OF COMET *a* 1895 (SWIFT),

MADE AT THE CHAMBERLIN OBSERVATORY, UNIVERSITY PARK, COLORADO,

BY HERBERT A. HOWE AND JOHN DICKERMAN.

University Park M.T.		*	No. Comp.	☄ − *		☄'s apparent		log *p*Δ	
				Δα	Δδ	α	δ	for α	for δ
1895	h m s			m s	′ ″	h m s	° ′ ″		
Dec. 4	6 55 14	*a*	8 , 5	−0 8.93	+23 13.7	1 45 54.10	+5 44 53.7	*n*9.342	0.696
7	9 20 2	*b*	10 , 5	−1 21.44	+ 9 30.5	1 48 31.20	+6 5 17.2	8.878	0.686
9	10 10 56	*c*	10 , 5	−3 10.60	+ 8 53.4	1 50 19.36	+6 19 7.5	9.265	0.688
12	8 0 12	*d*	10 , 5	−1 45.71	+11 47.1	1 53 0.31	+6 39 43.6	*n*8.722	0.678
	8 35 5	*e*	10 , 5	+7 40.16	−25 19.7	1 53 2.01	+6 39 37.6	8.222	0.678
	9 11 56	*f*	10 , 5	−3 24.34	+21 53.0	1 53 3.97	+6 39 58.6	8.952	0.680
	10 41 8	*g*	10 , 5	+4 55.18	−26 59.6	1 53 6.29	+6 40 25.6	9.402	0.680
14	8 0 15	*h*	10 , 5	−4 28.07	−20 22.5	1 51 54.69	+6 53 58.4	*n*8.610	0.676
	9 9 38	*i*	10 , 5	+8 42.03	− 9 32.9	1 54 59.10	+6 51 14.0	8.985	0.677
	9 47 55	*j*	10 . 5	−2 13.98	−22 54.3	1 55 0.51	+6 51 38.9	9.229	0.681
18	8 55 56	*k*	10 , 5	+2 31.32	+ 1 35.1	1 58 57.86	+7 23 32.1	8.968	0.671
	9 56 33	*l*	10 , 5	−0 17.05	+ 3 2.5	1 59 0.90	+7 24 10.0	9.315	0.678
19	7 59 8	*m*	10 , 5	−0 44.70	−14 22.1	1 59 58.91	+7 30 54.1	*n*8.146	0.668
	8 36 2	*n*	10 , 5	+1 28.25	− 4 55.8	1 59 59.62	+7 31 1.1	8.774	0.669
20	8 51 52	*o*	5 , 5	−4 17.27	−11 25.4	2 1 3.04	+7 38 24.5	8.983	0.668

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
a	1 45 58.91	+4.12	+5 21 14.0	+26.0	Boss. Albany Astr. Ges. Catal. 521
b	1 49 48.51	+4.13	+5 55 20.7	+26.0	Schjellerup 561
c	1 53 25.82	+4.14	+6 9 48.2	+25.9	Schjellerup 582
d	1 54 41.90	+4.12	+6 24 30.8	+25.7	Glasgow (1870) 434
e	1 45 17.78	+4.07	+7 5 1.3	+26.0	Schjellerup 542
f	1 56 21.18	+4.13	+6 17 40.0	+25.6	Schjellerup 595
g	1 48 7.02	+4.09	+7 6 59.2	+26.0	Glasgow (1870) 409
h	1 59 18.61	+4.15	+7 13 55.2	+25.7	Glasgow (1870) 452
i	1 46 13.00	+4.07	+7 3 21.0	+25.9	Paris 2316
j	1 57 10.36	+4.13	+7 17 7.5	+25.7	Brussels 782
k	1 56 19.41	+4.13	+7 21 31.3	+25.7	Paris 2532
l	1 59 13.81	+4.14	+7 20 41.9	+25.6	Weisse's Bessel I, 1014
m	2 0 39.46	+4.15	+7 44 50.5	+25.7	Yarnall (F) 979
n	1 58 27.24	+4.13	+7 35 31.2	+25.7	Glasgow (1870) 451
o	2 5 16.14	+4.17	+7 52 24.4	+25.5	Glasgow (1890) 166

The observations above were made with the 20-inch equatorial and filar micrometer, the magnifying power being 185. The entire set consists of 82 observations from August onward, the reductions of which are well advanced. All the observations were micrometrical measures of Δα and Δδ between the comet, and some faint star in the field of view. The star was then connected with a catalogue-star: for the catalogue-positions of the stars we are indebted to Prof. A. S. FLINT, of the Washburn Observatory, our library being meagre. The comet-comparisons were all made by the first-named observer. The connection of each comparison-star with a catalogue-star was carefully made by Mr. DICKERMAN, who also executed most of the reductions of the observations.

NOTES.

Dec. 4. Comet faint in moonlight and haze.
Dec. 7. Comet easily measured at times.
Dec. 9. Comet very faint in light haze.
Dec. 12. Comet fluffy and hard to bisect.
Dec. 14. Comet very difficult during first set of observations; nucleus not seen during second set; nucleus plain at one time during the third set.
Dec. 18. Comet fairly seen at times; at others almost invisible.
Dec. 19. Comet not excessively difficult.
Dec. 20. Definition poor; comet hard to see.

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PUBLISHED IN BOSTON, SEMI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed March 23.*

THE
ASTRONOMICAL JOURNAL.

No. 371.

VOL. XVI. BOSTON, 1896 APRIL 6. NO. 11

THE INFLUENCE OF ATMOSPHERIC AND OCEANIC CURRENTS UPON TERRESTRIAL LATITUDES,

By SIMON NEWCOMB.

Although the following theorem should be implicitly contained in the formula for the rotation of a spheroid carrying a fluid on its surface, I have nowhere seen it explicitly stated.

THEOREM. *Let an unconstrained, rigid sphere, with equal moments of inertia, be in a state of free rotation:*

Let this sphere bear on its surface a sheet or sheets of continuous movable matter:

Let this movable matter be kept in a state of steady motion relative to the sphere, by actions and reactions between it and the sphere, without the action of any external force:

Let P be the pole of the axis of rotation of the sphere, which will also be its momental axis:

Let Q be the momental axis of the total motions of the movable matter relative to the sphere:

Let I be the moment of inertia of the sphere, and M the total moment of momentum of all the movable matter around the axis Q:

Then shall the sphere take such a motion that the pole P, while remaining in a fixed direction in space from the center of the sphere, shall move steadily relatively to the matter of the sphere around the pole Q, with an angular velocity $\frac{M}{I}$

The application of this theorem to the case of the earth surrounded by its oceanic and atmospheric envelopes can now readily be seen. To obtain the value of M, we may roughly estimate the ratio of the moment of inertia of the earth to that of the ocean as 2600, and to that of the atmosphere as 1000000.

Observations, as discussed by CHANDLER, and interpreted by theory, indicate an annual change in the pole of the earth, which would be produced by a primary oscillation back and forth through a length of ten feet, or a revolution in a circle having a diameter of five feet. The former motion would, according to the theorem, be the necessary result of a general motion of the oceans on the two sides of the earth, which, at the point where the motion was a maximum, would be 2600 times as great. Approximately this motion would be represented by a continuous flow of the central parts of the Pacific ocean toward the pole of about 150 feet per day, with a correspondingly larger motion of the Atlantic in the opposite direction; followed by an opposite oscillation during the other six months. If, as may seem very likely, there cannot be so great a differential flow as this through Bering strait, and between the American and Asiatic continents, it will be necessary to suppose a more rapid flow elsewhere, or a sufficient vortex in the currents of the Atlantic and Pacific oceans. Whether the currents in these oceans are deep enough to produce the observed effect must be left to hydrographers to decide.

Passing to the atmosphere, the excess of motion through one season over that of the other season, to and from the north direction, amounting to 4000 miles in six months, or say twenty miles per day, would also account for the observed change. In these statements respecting the required motions of the earth and atmosphere, I have presupposed a motion around an invariable momental axis. If the motions are such that their momental axis moves around the earth in the course of a year, the required differential motions between the opposite seasons would be only half as great.

In what precedes I have spoken of the earth as a sphere, and considered only differential motions. The actual earth being a spheroid, the motion of the pole already described would not be continuous. The actual effect of oceanic and atmospheric currents of a permanent character on the terrestrial spheroid would be to displace the mean pole of the earth from its pole of figure to such a point of equilibrium that the motion described in the theorem would be neutralized by an equal and opposite Eulerian motion, due to the ellipticity of the spheroid. The actual effect would be a revolution of the terrestrial pole, according to the known laws of rotation, around the central point of equilibrium thus fixed in 427 days. Just what the displacement is can be only a matter of guess-work; from the known magnitude of the ocean currents they might produce a displacement ranging from ten to twenty feet.

A brief statement of the character of the theoretical variations of the latitude, due to these causes, may not be inappropriate. Since the directions of the currents of the air and ocean go through an annual period, we should expect a corresponding period in the latitude. Since, however, the amount of the annual change varies irregularly from year to year, though remaining constant in the general mean, the amplitude of the annual term should be subject to small variations from time to time, while preserving its mean value unchanged from age to age.

On the other hand, the amplitude of the Eulerian motion being permanently increased or diminished by every meteorological change, may be expected to vary its amplitude in a slow and irregular manner from decade to decade. The Eulerian motion, having a period of 427 days, ought to be nearly circular, unless the equatorial moments of inertia of the earth differ much more than we can suppose probable. The annual motion may differ somewhat from a circle, and be somewhat less regular. There can be no strictly periodic changes in the latitude but these two, but it is quite possible that, owing to secular changes, or changes continued through several years, in the currents of the ocean and atmosphere, corresponding changes of irregular long period may be found in the latitude.

It will be seen that these conclusions are accordant with Chandler's results as regards the double period, but do not fully agree with them in other details.

OBSERVATIONS OF VARIABLE STARS OF LONG PERIOD,

By EDWIN F. SAWYER.

The following observations of variable stars were mainly made during the year 1894. The present list consists of the stars of long or irregular periods. A second article to follow will contain the observations of those of short period. Owing to the press of other astronomical work on our leisure time, notably the revision of the star magnitudes in Müller and Kempf's Photometric Catalogue, some delay has necessarily occurred in the reduction and publication of the variable star results. The 1895 results will be published as soon as time permits.

100. *T Ceti.*

This star was under observation from 1893 November 6 to 1894 January 1. Gaps occur in the series, extending from November 11 to December 2, and from December 10 to 24. The observations number 9. When first seen on November 6, *T* was = 10 (*U.A.*) *Ceti*, and 2 or 3 steps >28 (*U.A.*) *Ceti*, or $6^{M}.2$. The light remained apparently constant until December 10. When next observed, December 20, *T* was found somewhat fainter, being 2 steps <28 (*U.A.*) *Ceti*, and one step >31 (*U.A.*) *Ceti*, or $6^{M}.7$. No further change was recorded up to the time the observations ended.

806. *o Ceti.*

The observations on this star extend from 1893 December 31 to 1894 February 11, and number 10. When first seen *o* was 5 steps <SDM. −4°379, or about $9^{M}.0$. The light increased quite rapidly after January 7. When last observed on February 11, it was 3 steps >244 (*U.A.*) *Ceti*, and 3 steps <234 (*U.A.*) *Ceti*, or $6^{M}.8$. It had evidently not reached a maximum.

1072. *ρ Persei.*

The observations on this star number 37, and extend from 1894 October 1 to 1895 January 20. The star was at its normal brightness when first seen on October 1. The light faded after October 11, and a bright minimum was reached October 28. The decrease was about 4 steps. The light rapidly recovered after November 1, and on the 15th *ρ* had again reached its normal brightness, where it remained until the observations ended.

2100. *U Orionis.*

This star was first observed 1893 December 29, and found to be 4 steps <DM. 20°1168, or about $9^{M}.0$. The increase was quite rapid and uniform, a faint maximum being reached 1894 February 21, the maximum brightness being 2 steps >DM. 19°1106, and 3 or 4 steps <DM. 20°1156, or $7^{M}.3$. The light remained nearly constant 37 days, or from January 30 to March 7. An apparent depression of a step or two has been ignored in drawing the light-curve. The light slowly faded after March 7 and, when last observed on April 3, *U* was 5 steps <DM. 20°1156, or $7^{M}.7$. The observations number 33.

3493. *R Leonis.*

Nine observations were obtained on this star, extending from 1894 April 23 to June 3. When first seen *R* was = DM. 12°2105, and 3 steps <12°2095, or $7^{M}.0$. The light increased quite rapidly, and a faint maximum was passed May 4, the maximum brightness being 2 or 3 steps >DM 12°2105, and = DM. 12°2095, or $6^{M}.7$. The star remained at maximum only 7 or 8 days, the light rapidly fading, and when last seen was 5 steps <DM. 12°2105, and 3 steps >DM. 12°2102, or $7^{M}.4$.

3796. *U Hydrae.*

This star was observed on 13 evenings, extending from 1894 March 3 to June 1. The only phase determined was a minimum, which was reached April 14.

3825. *R Ursae Majoris.*

Observed from 1894 July 3 to September 21, nine observations. A serious gap occurs in the series, extending from August 5 to September 21. When first seen *R* was

5 steps < DM. 70°622, or about 8^{M}.8. The light increased quite rapidly until July 22, when *R* was = DM. 69°577, and 4 steps > DM. 69°584, or 7^{M}.8. The light remained stationary until the break in the observations August 5. The time of maximum is quite uncertain, but probably occurred about August 4. When last seen on September 21, *R* was = DM. 69°584, or about 8^{M}.3.

4847. *S Virginis.*

This star was under observation from 1894 April 23 to July 2, 22 observations being secured. When first seen *S* was 3 steps < SDM. −6°3834, or about 8^{M}.8. The increase was rather slow, a maximum being passed May 25, the maximum brightness being 2 steps > SDM. −6°3843, and = SDM. −5°3713, or 8^{M}.0. The light faded very slowly after May 29, and when last seen, on July 2, *S* was 5 steps < SDM. −6°3843, and = SDM. −6°3834, or 8^{M}.6.

4940. *W Hydrae.*

This star when first seen, 1894 March 27, was 3 steps < Gould G.C. 18788, or 7^{M}.7. The increase up to May 12 was very slow, but afterwards and up to the time the observations terminated June 21, the rise was quite rapid. When last seen *W* was 3 steps > 364 (*U.A.*) *Hydrae* and = 361 (*U.A.*) *Hydrae*, and 3 steps < 359 (*U.A.*) *Hydrae*, or 6^{M}.6. The time of maximum is very uncertain, but was probably passed about the middle of June. The observations number 11.

5667. *R Coronae.*

R was first observed 1894 March 26, and found to be = DM. 28°2469, or about 7^{M}.9. The light remained constant until April 5, when a fall of two steps occurred. A break in the series extends to April 29, on which date *R* was found to be about 7^{M}.7, having brightened about 4 steps. The light faded again after May 3. From May 12 another rise to 7^{M}.6 occurred. After June 3 the decrease was very rapid, and on the 19th *R* was last observed, and estimated to be about 9^{M}.0. The star was next seen on August 31, and found to be 1 step < DM. 28°2475, or 7^{M}.5. The light increased quite rapidly and regularly, until the observations ended, October 18, when *R* had reached its normal brightness, or 4 or 5 steps < DM. 32°2621, and 4 steps > DM. 30°2682, or 6^{M}.3. The observations number 26.

5758. *X Herculis.*

A good series of observations, numbering 60, was obtained on this star, extending from 1894 March 27 to November 22. From these two maxima and one minimum have been determined. The first maximum was passed July 3, and the second October 23, the interval being 112 days. The minimum was reached September 10. Another minimum was apparently passed about April 14 ±.

5912. *g Herculis.*

The observations on this star number 58, and extend from 1894 April 23 to October 31. Maxima are indicated for May 20, July 17 and September 20, the intervals being 58 and 65 days respectively. Minima were passed June 22 and August 15, the interval being 55 days. The first and third maxima were fairly bright, while the second was quite faint. The minima were both rather bright.

6733. *R Scuti.*

The observations on this star number 64, and extend from 1894 May 8 to November 29. Serious gaps occur in the series, extending from May 9 to 27, June 8 to 20, July 10 to 22, and September 7 to 20. The charted observations, however, permit the certain determination of two maxima and two minima. The first maximum from a rapid rise was passed September 8, and was rather bright. The second maximum, a very bright one, was reached November 8, the interval being 61 days. The first minimum, a faint one, was passed August 8, and the second, a bright one, was passed October 13, the interval being 67 days.

6794. *R Lyrae.*

A good series of observations, 88 in number, was obtained on this star, extending from 1894 May 22 to 1895 January 17. From these 3 maxima and 4 minima have been determined. The maxima were passed July 9, September 1 and November 29. A fourth maximum is also indicated about October 4 ±, but this is somewhat uncertain, the observations exhibiting rather conflicting results. In the case of the third maximum, which was a very bright one, the light from maximum very suddenly declined seven steps in two days. The four minima were passed August 9, September 19, November 4 and December 23.

6849. *R Aquilae.*

This star was under observation from 1894 June 1 to August 5, 19 observations being obtained. When first seen, on June 1, *R* was 5 + steps < DM. 8°3951, and = DM. 8°3956, or about 7^{M}.5. The light increased quite rapidly, and somewhat irregularly, a maximum being passed July 9, the maximum brightness being 2 or 3 steps > DM. 8°3951, or about 6^{M}.2. The decrease was quite rapid, and when last seen *R* was 5 steps < DM. 8°3951, or 7^{M}.2.

7085. *RT Cygni.*

The observations on this star number 12, and extend from 1894 June 1 to August 6. Gaps occur in the series, extending from June 7 to 20, and from June 21 to July 22. A maximum is indicated about June 21. Comparison-stars not yet identified.

7120. *χ Cygni.*

A very good series of observations on this star was secured, extending from 1894 November 27 to 1895 January 19, and numbering 23. When first seen, on November 27, *χ* was 1 step > DM. 33°3602, and 2 steps < DM. 32°3558, or 6^{M}.7. The increase was quite rapid and uniform, a maximum being passed December 26.5, the maximum brightness being 5 steps >DM.33°3587, 2 steps <DM.34°3590 and 5 + steps <DM.34°3798, or 4^{M}.8. The light remained stationary 16 days. The decrease was also quite rapid, and when last seen, on January 19, χ was 2 steps <DM. 33°3587, and 5 steps >DM.32°3521, or 5^{M}.5.

7754. *W Cygni.*

The observations on this star extend from 1894 April 5 to 1895 January 17, and number 60. These when plotted exhibit the following maxima and minima. The first maximum of average brightness was passed August 13. A second maximum of about the same brightness was reached about December 5. The first minimum, a very faint one, was reached June 25. A second minimum, somewhat brighter, was passed about October 11. The interval betweed the two maxima was 114 days, and between the two minima 108 days.

Brighton, 1896 *January* 30.

OBSERVATIONS OF SOUTHERN VARIABLES,

BY H. M. PAUL.

7139. *RR Sagittarii.*

I have 10 observations, showing a fairly smooth descent from about 7^{M}.8 on 1895 Aug. 18 to about 10^{M}.2 on Nov. 13. They do not cover either a maximum or minimum, but seem to be fairly accordant with CHANDLER's elements [*A.J.* XV, 81], which give maximum E(+4) on 1895 June 9, though perhaps indicating that this maximum may have been brighter than 7^{M}.5.

7266. *RT Sagittarii.*

The necessary change in the CHANDLER number of this star, due to the error in the H.C.O. position, has been provided for in a foot-note to CAMPBELL's observations [*A.J.* XVI, 24].

I have 18 observations of the star, all falling on a descending curve from 7^{M}.62 on 1895 July 10 to 11^{M}.35 on Nov. 12. There are considerable departures from a smooth descent in this curve, but whether real, or only errors of observation, future observation must determine.

Although no maximum or minimum has yet been published, I find that the six H.C.O. plates [*A.N.* 125: 366], THOME's C.DM. observations [*A.J.* XV, 197], CAMPBELL's observations [*A.J.* XVI, 24], and my own, are all fairly well satisfied by the following provisional formula for maxima,

$$1895 \text{ July } 5 = 241\,3380^{d} + 311^{d}\,\mathrm{E},$$

with an approximate range of 7^{M}.5 – <11^{M}.

The companion to *RT* referred to by me [*A.J.* XV, 133], by THOME [*A.J.* XV, 197], and by CAMPBELL [*A.J.* XVI, 24], comes out about 10$\frac{1}{4}^{M}$ in my scale, making it pretty certain that the photographic magnitude 10^{M}.7 measured from the H.C.O.-Chosica plate of 1889 Oct. 14 [*A.N.* 125: 366], refers to this companion, and not to *RT*, or else to their joint light. The date falls 88^{d} after maximum E(−7) of the above rough elements. The presence of this companion will always make observations of minima difficult.

7404. *R Microscopii.*

I have observed this star on 22 nights, between 1895 July 9 and Dec. 13, the observations covering more than one period, and falling pretty accordantly on a curve which gives

Min. 12^{M}.0 1895 Sept. 10 = 241 3447
Max. 8.0 Nov. 12.6 = 3510.6

$$M - m = 64^{d}$$

From the H.C.O. photographic magnitudes, published in *A.N.* 137: 74, and THOME's two C.DM. observations [*A.J.* XV, 197], I have deduced the following formula for Greenwich times of maxima,

$$1895 \text{ Nov. } 12.6 = 241\,3510^{d}.6 + 138^{d}.8\,\mathrm{E}.$$

While this agrees only tolerably well with the H.C.O. and C.DM. observations, indicating either great uncertainty in the photographic magnitudes, or else a considerable range of brightness at different maxima, no other constant period will suit them as well.

The faintest of my comparison-stars (which comes out about 12^{M}.2 in my light-scale) is only about +2^{s} and +0′.3 from the variable, and between them is a still closer companion of about the same magnitude. It would be well for observers with large telescopes in the southern hemisphere to measure the position-angles and distances of these three stars, and carefully to estimate their magnitudes at times when *R* is near minimum.

7999. *X Aquarii.*

I have 23 observations, showing a fairly smooth descent from 8^{M}.5 on 1895 July 9 to about 12^{M}.7 on Dec. 14, the curve indicating that maximum was already passed on the first date, and minimum probably not reached on the last. No later observations were possible here.

I find the following formula for maxima,

$$1895 \text{ June } 20 = 241\,3365^{d} + 311^{d}\,\mathrm{E},$$

with an approximate range of 8^{M}.3 – 13^{M}, will suit moderately well the 18 H.C.O. plates [*A.N.* 138: 179], YENDELL's observations [*A.J.* XV, 157], and my own, though the elements can be only a rough approximation, no maximum or minimum having yet been observed.

As the star is in no catalogue, I have tied it to the 7^{M}.7 star about 10′ north [Radcliffe (90) 5994] with the resulting position below,

For 1900.0 22^{h} 13^{m} 9^{s}.3 −21° 24′.0
1855.0 10 40.2 37.4

differing by −3^{s} and +2′ from the H.C.O. position in *A.N.* 138: 179.

Washington, 1896 *March* 2.

RELATIVE POSITIONS OF "NOVA," *Z CENTAURI*, NEBULA N.G.C. 5253 AND THREE NEIGHBORING STARS,

By WILLIAM J. HUSSEY.

On the nights of 1895 December 22, and 1896 January 2, before I had begun my work at the Observatory, Professor Campbell had measured the relative positions of *Nova Centauri*, Nebula N.G.C. 5253, and three neighboring stars, and had compared the Nova's position with Cord. Z.C. $13^{h}2134$. Since then I have repeated the measurements of relative positions on six nights, and have compared the Nova and Cord. Z.C. 2134 in right-ascension two nights, and in declination three nights. Cord. Z.C. 2134 is the only catalogued star within convenient reach of the micrometer.

The three stars whose positions relative to the Nova have been measured, are denoted below by *A*, *B* and *C*. *B* and *C* are not catalogued; *A* is C.DM. −31°10534. The magnitudes are estimated as follows: *A*, $9^{M}.7$; *B*, 10^{M}; *C*, $10^{M}.5$; N.G.C. 5253, $9^{M}.5$ (in finder with low power), and

New Star.

	M	
1895 Dec. 22	11.2	Campbell
29	11.2	"
1896 Jan. 1	11.2	"
2	11.2	"
27	11.3	"
Feb. 5	11.4	"
7	11.5	"
8	11.5	Hussey
11	11.5	"
14	11.5	"
19	11.5	"

The magnitudes of *B* and *C* have been estimated with reference to *A*, and the Nova with reference to *C*, and, therefore, the Nova estimates are relative rather than absolute.

Our measurements give the following differences of right-ascension and declination.

Nebula — Nova		*A* — Nova		*B* — Nova		*C* — Nova		Nova — Cord. Z.C. $13^{h}2134$		
Δα	Δδ	Δα	Δδ	Δα	Δδ	Δα	Δδ	Δα	Δδ	Observer
s	″	s	″	s	″	s	″	m s	′ ″	
−1.40	−18.0	−13.98	−3.5	−1.79	+74.2	+8.62	+57.5	−2 30.65	−6 16.1	Campbell
−1.35	−18.0	−14.01	−3.6	−1.85	+74.2	+8.68	+58.4	−2 30.39	−6 18.2	Hussey

For the epoch 1875.0 we have the following positions:

Object	α (1875.0)	δ (1875.0)	Remarks
	h m s	° ′ ″	
C.DM. −31°10534	13 32 36.7	−31 0.3	Catalogue-position
" "	37.90	0 0.6	Observed "
" −31°10536	32 49.6	−31 0.3	Catalogue "
Nebula N.G.C. 5253	13 32 50.8	−31 0.2	Catalogue "
" " "	50.48	0 15.3	Observed "
New Star	13 32 51.74	−31 59 56.8	Observed, Campbell
" "	52.01	58.6	Observed, Hussey

In our four-inch finder, power 20±, the appearance of the nebula is such that it might easily be mistaken for a star, magnitude 9.5, though careful observation shows it to be somewhat hazy. This finder is comparable with the instrument used at Cordoba in constructing the C.DM. The close agreement of the nebula and C.DM. −31°10536, both in magnitude and position, renders it all but certain that the C.DM. star refers to the nebula.

Mt. Hamilton, Cal., 1896 *March* 7.

FIVE NEW SOUTHERN VARIABLES,

By ROBERT H. WEST.

$\alpha = 0^{h}\,43^{m}\,29^{s}.5$; $\delta = -35°\,36'.0$ (1875.0).

My attention was attracted to this star by its absence from the Cordoba *Durchmusterung* chart. The following observations indicate that it is a variable, and that it passed a maximum of $9^{M}.1$ on or about 1895 Dec. 17.

	M		M
1895 Nov. 28	9.4	1896 Jan. 7	9.4
Dec. 4	9.3	28	9.7
17	9.1	Feb. 4	9.85
21	9.2	6	10.05*
27	9.3	10	10.15*
1896 Jan. 2	9.3		

* Twilight.

The following stars are given in the list of suspected variables in the introduction to the Cordoba *Durchmusterung*, and their variability is confirmed by my observations. With these, as with the preceding, the C.DM. magnitudes of the neighboring stars have been taken as standards, after revision, however, when it has seemed necessary.

C.DM. −30°375.

$\alpha = 1^{h}\,5^{m}\,38^{s}.6$; $\delta = -30°\,46'.8$ (1875.0).

The Cordoba observations are

1886 Aug. 30	$9^{M}.0$	1890 Dec. —	invisible
1887–8	invisible	1892 Jan. 2	$8^{M}.7$

My observations are

	M		M
1895 Nov. 22	10.0	1895 Dec. 28	11.8
25	10.6	1896 Jan. 7	12.0*
Dec. 4	11.4	13	12.5*
13	11.4		

* Estimated.

The star has been seen since Jan. 13, but its rapidly decreasing altitude is sufficient explanation of its invisibility, without any further decrease in magnitude.

C.DM. −26°892.

$\alpha = 2^h\,23^m\,39^s.8 \;;\; \delta = -26°\,39'.2$ (1875.0).

The Cordoba observations are

		M
1886 Oct. 23	Nov. 13, 14	10.0
1887 Sept. 11		8.5
1891 Dec. 27		8.7

Eleven observations show a slow but steady increase from $9^M.65$ on 1895 Nov. 8, to $8^M.75$ on 1896 Feb. 10. The star is quite red, being about the same color, to my eye, as 3128 *R Pyxidis*, which is given as 6 in CHANDLER's Catalogue.

C.DM. −25°1602.

$\alpha = 3^h\,45^m\,10^s.8 \;;\; \delta = -25°\,20'.2$ (1875.0).

The Cordoba observations are

	M
1886 Oct. 24	8.5
1891 Nov. 30	invisible
Dec. 3	9.7

The following are my observations:

	M		M
1895 Dec. 17	9.6	1896 Jan. 13	10.9
26	9.8	Feb. 4	11.1
1896 Jan. 2	10.7	10	11.4
7	10.8		

C.DM. −31°2732.

$\alpha = 5^h\,42^m\,14^s.2 \;;\; \delta = -31°\,44'.3$ (1875.0).

The Cordoba observations are

	M
1887 Nov. 16	8.0
1888 Dec. 25	10.0
1892 Nov. 13	invisible

My observations are as follows:

	M		M
1895 Dec. 21	9.1	1896 Jan. 13	9.75
26	9.25	29	9.9
1896 Jan. 3	9.35	Feb. 4	10.0
7	9.5	10	10.1

Syrian Protestant College, Beirut, Syria, 1896 *Feb.* 11.

MERIDIAN-CIRCLE OBSERVATIONS OF COMPARISON-STARS FOR COMET *c* 1895,

BY R. H. TUCKER.

The two stars used in the comparison of 1895 Nov. 19, (*A.J.* 360), have been observed with the meridian circle. The places, magnitudes and precessions, follow.

M	α 1896.0 h m s	Prec. s	δ 1896.0 ° ′ ″	Prec. ″
8½	13 50 49.78	+3.071	+0 7 0.1	−17.75
9	13 52 3.28	+3.071	+0 10 6.2	−17.70

OBSERVATIONS OF COMET *c* 1895 (PERRINE),

MADE AT THE LICK OBSERVATORY WITH THE 36-INCH AND 12-INCH EQUATORIALS.

BY C. D. PERRINE.

1896	Mt. Hamilton M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Jan. 30	17 58 36	23	3 , 3	+0 4.04	+4 15.6	19 40 22.11	−6 15 34.7	*n*9.659	0.741
	18 5 25	25	5 , 5	−0 15.19	+2 39.5	19 40 22.30	−6 15 30.3	*n*9.655	0.743
Feb. 3	18 2 0	26	8 , 6	+0 5.92	+1 35.5	19 41 52.32	−5 5 9.4	*n*9.648	0.742
4	17 48 15	28	6 , 5	+0 19.95	+2 38.2	19 42 13.97	−4 47 57.5	*n*9.654	0.740
5	17 57 29	30	6	+1 54.52	. . .	19 42 34.18	. . .	*n*9.646	. .
	18 11 55	30	4	. . .	−4 14.9	. . .	−4 30 32.7	. .	0.742
6	17 56 41	31	8 , 5	+2 43.35	+2 5.7	19 42 54.05	−4 13 38.7	*n*9.643	0.741
7	17 46 34	32	18 , 5	+1 51.84	−1 37.0	19 43 13.14	−3 56 48.6	*n*9.648	0.739
8	17 44 18	33	18 , 7	+1 32.80	+2 40.2	19 43 32.05	−3 40 0.2	*n*9.647	0.737
10	17 47 27	34	8 , 4	+3 40.59	+1 54.7	19 44 6.31	−3 6 23.4	*n*9.639	0.738
11	17 36 38	35	22 , 6	−1 22.92	−6 13.2	19 44 22.66	−2 49 49.1	*n*9.645	0.736
12	17 40 36	36	10 , 5	+3 6.80	−1 30.7	19 44 38.71	−2 33 7.8	*n*9.639	0.736
13	17 37 40	37	12 , 4	−1 45.61	+8 42.0	19 44 53.55	−2 16 38.2	*n*9.638	0.734
14	17 19 56	37*a*	3	. . .	+4 55.1	. . .	−2 0 20.4	. .	0.726
15	17 32 23	38	14 , 7	+1 6.24	+5 14.6	19 45 20.68	−1 43 37.2	*n*9.637	0.732
16	17 35 2	39	14 , 7	−1 24.73	+5 14.3	19 45 33.34	−1 27 17.1	*n*9.631	0.735
17	17 3 55	40	10 , 4	−4 5.75	−4 3.8	19 45 44.12	−1 11 0.4	*n*9.651	0.732
18	17 6 25	41	11 , 6	−1 0.75	−2 34.4	19 45 55.20	−0 54 42.2	*n*9.646	0.731
21	16 44 26	42	10 , 4	−3 2.84	−5 50.3	19 46 22.19	−0 5 54.1	*n*9.653	0.728
22	17 7 18	43	10 , 4	+1 31.10	−0 50.4	19 46 29.60	+0 10 40.6	*n*9.635	0.728
23	17 27 34	44	10 , 4	+1 17.74	−0 18.9	19 46 36.51	+0 27 3.3	*n*9 613	0.725
24	16 51 18	45	14 , 6	−0 29.34	−0 57.1	19 46 40.96	+0 13 10.3	*n*9.639	0.725
Mar. 7	17 17 36	46	9 , 4	−0 44.31	−0 36.0	19 46 24.20	+4 0 19.4	*n*9.556	0.700
10	16 59 56	47	5 , 5	+0 3.00	+0 11.5	19 45 51.67	+4 49 51.6	*n*9.569	0.696
17	16 42 3	48	10 , 4	+0 50.95	+5 22.1	19 43 58.39	+6 46 58.8	*n*9.553	0.680

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	s	
23	19 40 18.51	−0.44	−6 20 0.4	−10.1	Micrometer-comparisons with (24)
24	19 43 41.75	−0.44	−6 17 13.8	−10.1	Dunsink obsns.. 6th part (1012 stars) No. 756
25	19 40 37.93	−0.44	−6 17 59.7	−10.1	Micrometer-comparison with (24)
26	19 41 46.79	−0.39	−5 6 34.4	−10.5	" " " (27)
27	19 38 48.07	−0.39	−5 2 21.5	−10.6	Munich I, 21572
28	19 41 54.40	−0.38	−4 50 25.1	−10.6	Micrometer-comparison with (29)
29	19 43 26.72	−0.38	−4 45 17.1	−10.5	Schjellerup 7613
30	19 40 40.02	−0.36	−4 26 7.1	−10.7	Munich II, 9234
31	19 40 11.04	−0.34	−4 15 33.7	−10.7	Schjellerup 7581
32	19 41 21.59	−0.32	−3 55 0.8	−10.8	½ (Radcliffe$_3$ 5284 + Munich II, 9251)
33	19 41 59.53	−0.28	−3 42 29.6	−10.8	Schjellerup 7598
34	19 40 25.97	−0.25	−3 8 7.0	−11.1	½ (Argent. G.C. 27081 + Radcliffe$_3$ 5278)
35	19 45 45.83	−0.25	−2 43 24.9	−11.0	½ (Radcliffe$_3$ 5305 + Argent. G.C. 27194)
36	19 41 32.13	−0.22	−2 31 25.8	−11.3	Munich I, 21744
37	19 46 39.37	−0.21	−2 25 9.0	−11.2	W. Bessel XIX, 1130
37*a*	19 43 15.03	−0.19	−2 5 4.0	−11.5	Radcliffe$_3$ 5295
38	19 44 14.62	−0.18	−1 48 40.2	−11.6	⅓ (Munich I, 21914 + 2 Schjellerup 7620)
39	19 46 58.25	−0.18	−1 32 19.8	−11.6	W. Bessel XIX, 1136
40	19 49 50.04	−0.17	−1 6 45.0	−11.6	⅓ (2 Schjellerup 7675 + Munich I, 22258)
41	19 46 56.10	−0.15	−0 51 56.0	−11.8	⅓ (2 Copeland and Börgen 5449 + Mun. I, 22084)
42	19 49 25.12	−0.09	+0 0 8.2	−12.0	½ (Radcliffe$_3$ 5325 + Argent. G.C. 27275)
43	19 44 58.55	−0.05	+0 11 43.2	−12.2	½ (Munich I, 21961 + W. Bessel XIX, 1088)
44	19 45 18.80	−0.03	+0 27 34.5	−12.3	W. Bessel XIX, 1096
45	19 47 10.31	−0.01	+0 44 19.7	−12.3	½ (Radcliffe$_2$ 1907 + Glasgow 4926)
46	19 47 8.27	+0.24	+4 1 8.9	−13.4	Boss, Albany A.G. Catal. 6880
47	19 45 51.35	+0.32	+4 49 53.9	−13.8	" " " " 6869
48	19 43 7.06	+0.38	+6 41 51.1	−14.4	⅓ (2 Schjellerup 7607 + Munich I, 21842)

The observations of Jan. 30, Feb. 3, 4 and 5, were made with the 36-inch equatorial, as the 12-inch telescope was dismounted. The Δα on Jan. 30, Feb. 3, 4, March 10, were measured directly with the micrometer. The observations of Feb. 5 were made in a high north wind. On Dec. 20 the comet was seen east of the sun, but too near the horizon to measure.

ERRATA IN STAR CATALOGUES.

By C. D. PERRINE.

S.DM. —6°5269 is stated to be in Weisse's Catalogue of BESSEL'S stars, but is not found there.

Weisse's Bessel I, XIX, 1088. RUNKLE in his list of errata published in the *Astronomical Journal*, vol. 3, page 115, changes the declination of this star. I used it as a comparison-star in observing Comet *c* 1895, and find that its place as given in Weisse's catalogue agrees with the Munich reductions of LAMONT'S observations of this star, and also with BESSEL'S original zone observations. Hence RUNKLE'S correction seems to be erroneous.

Lick Observatory, 1896 *March* 21.

OBSERVATIONS OF COMET *a* 1896,

MADE AT THE LICK OBSERVATORY,

BY WILLIAM J. HUSSEY.

1896 Mt. Hamilton M.T.	*	No. Comp.	☄ − *		☄'s apparent		log *p*Δ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Feb. 19 17 46 54	1	7 , 7	+2 49.49	−3 2.8	20 15 11.78	+15 29 50.9	*n*9.6497	0.6442
24 17 3 45	2	10 , 10	+1 23.29	+1 16.4	21 55 6.21	+38 27 2.2	*n*9.7713	0.6774
Mar. 7 9 36 29	3	9 , 9	+2 11.19	−3 56.4	2 16 43.09	+50 45 7.2	9.8654	0.5977
9 36 29	4	9 , 8	−1 42.22	−1 38.0	2 16 43.06	+50 45 9.4	9.8654	0.5977
8 9 42 44	5	4	. . .	+0 47.9	. . . .	+50 19 42.6	. . .	0.5986
10 3 32	5	4	−3 7.57	. . .	2 28 34.84	. . . .	9.8584	. .
9 8 53 20	6	11 , 22	−0 7.73	+5 46.6	2 38 25.96	+49 51 24.8	9.8576	0.4319
10 7 46 11	7	7 , 12	+0 53.58	+2 19.8	2 47 18.47	+49 25 1.5	9.8108	0.0298
13 7 13 5	8	10	. . .	+9 11.1	. . . .	+48 3 13.2	. . .	9.8555
7 28 1	8	8	+0 31.66	. . .	3 9 52.96	. . . .	9.7573	. .
17 8 48 50	9	4	. . .	+9 16.8	. . . .	+46 23 45.3	. . .	0.3928

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	20 12 22.72	−0.13	+15 33 6.4	−12.7	Rümker 8159 [+Rümk. 9710)
2	21 53 44.10	−1.18	+38 25 51.8	− 6.0	¼ (Gl.$_2$ 1903 + W. Bessel XXI, 1275 + Y. 9896
3	2 14 32.40	−0.50	+50 48 47.1	+16.5	Rogers, Cambridge Astr. Ges. Catal. 1096
4	2 18 25.82	−0.54	+50 46 31.1	+16.3	" " " " " 1122
5	2 31 42.77	−0.36	+50 18 37.9	+16.8	" " " " " 1215
6	2 38 33.96	−0.27	+49 45 21.3	+16.9	Deichmüller. Bonn Astr. Ges. Catal. 2343
7	2 46 25.11	−0.22	+49 22 24.6	+17.1	" " " " " 2457
8	3 9 21.32	−0.02	+47 53 41.8	+17.3	" " " " " 2730
9	3 28 48.44	+0.11	+46 14 11.7	+16.8	" " " " " 3025

The observations of Feb. 19 and 24 were made with the 36-inch telescope: the others with the 12-inch. On March 9, 10 and 13. Δα was measured with micrometer.

EPHEMERIS OF COMET *α* 1896,

By WILLIAM J. HUSSEY.

This is a continuation of the ephemeris sent for publication March 3. It is derived from my elements of the orbit, computed from observations of Feb. 15, 20 and 25, Greenwich M.T. The correction to the ephemeris on Mar. 23 was, $\Delta\alpha = -1^s$, $\Delta\delta = +0'.3$.

Ephemeris for Greenwich Midnight.

1896	App. α	App. δ	log Δ	Br.
	h m s	° ′		
April 24.5	4 50 17	+39 41.6	0.3600	0.008
26.5	52 42	33.1	.3707	
28.5	55 4	25.3	.3811	0.007
30.5	4 57 23	+39 18.2	0.3910	
May 2.5	4 59 39	+39 11.4	0.4005	0.006
4.5	5 1 53	39 5.2	.4096	
6.5	4 4	38 59.5	.4183	.005
8.5	6 13	54.2	.4267	
10.5	8 20	49.4	.4347	.005
12.5	10 26	44.9	.4425	
14.5	12 29	40.8	.4499	.004
16.5	14 31	37.0	.4570	
18.5	16 32	33.5	.4638	.003
20.5	18 29	30.4	.4704	
22.5	5 20 25	+38 27.3	0.4763	0.003

COMETS OF THE YEAR 1895.

The dates are in Greenwich Mean Time and the Elements only approximate.

Designation	Perihelion	☊	ω	i	q	φ	Discoverer	Date	Synonym	
		° ′	° ′	° ′		° ′				
I	Feb. 7.74	334 45	183 57	12 54	0.3411	57 48	Cerulli	Nov. 1	*d* 1894	Encke's
II	Aug. 20.75	170 18	167 42	3 0	1.2975	40 44	Swift	Aug. 20	*a* 1895	Periodic
III	Oct. 21.05	83 5	298 46	76 15	0.8431	. .	Brooks	Nov. 21	*d* 1895	
IV	Dec. 18.33	320 26	272 36	141 39	0.1923	. .	Perrine	Nov. 17	*c* 1895	

The periodic comet of Faye (*b* 1895), first seen by Javelle, Sept. 26, passed its perihelion in 1896 (March 19).

CORRIGENDA.

No. 368, p. 57, col. 1, lines 6 and 18 *for* *Com.* *put* *Conn.*
col. 2, l. 8 *put* $m' = \frac{1}{1050}$

No. 368, p. 59, col. 1, l. 10, place the word "Then" before equation for *f*
p. 62, col. 1, l. 6, *for* ☊δ *put* δ☊

No. 369, p. 71, *for* No. 2778 α 1900, $7^h 43^m 4^s$ Ann. var., $2^s.99$, α 1855, $7^h 40^m 49^s.$
put " 2776 " $7^h 42^m 39^s$ " $1^s.99$, " $7^h 41^m 9^s.$ } Kindly pointed out by Prof. E. C. Pickering.

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Published in Boston, tri-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume Press of Thos. P. Nichols, Lynn, Mass
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed April 4.*

THE

ASTRONOMICAL JOURNAL.

No. 372.

VOL. XVI. BOSTON, 1896 APRIL 16. NO. 12

ECLIPSES AND CHRONOLOGY,

BY JOHN N. STOCKWELL.

Plutarch, in his "*Dissertation upon the Lunar Spots*," speaks of an eclipse of the sun which had *recently* happened about midday. He states that the darkness was so great that stars became visible in all directions. It must, therefore, have been either total, or very nearly total, at the place of observation.

The determination of the date of this eclipse has hitherto baffled the efforts of all astronomers. It is known, however, that Plutarch was born about the middle of the first century A.D.; but the date of his death is unknown. It probably occurred before the year A.D. 130; and the eclipse must have happened between the years A.D. 70, and A.D. 130. But if we examine all the eclipses which took place during the hundred years following the year A.D. 50, we shall find only one which corresponds to the narrative of Plutarch; and that took place A.D. 118 Sept. 3. According to my computation, that eclipse was central, and total at noon in longitude 27° 45′ east of Greenwich, and latitude 42° 38′ north; and at Chaeronea, the residence of Plutarch, its magnitude was more than 10½ digits. It took place at $11^h\ 34^m$ in the morning, or only twenty-six minutes before noon, and thus corresponds very perfectly with Plutarch's narrative concerning it. I think we may, therefore, confidently affirm that Plutarch's eclipse took place A.D. 118, Sept. 3.

Another eclipse of very great importance from a chronological point of view is mentioned by Zosimus. It is well known that Theodosius the Great survived the battle and victory over Eugenius only till the following January; during which period the Roman world was again for a brief moment under the control of a single emperor. The date of that great battle, therefore, determines the date of the death of Theodosius, and the beginnings of the reigns of Arcadius and Honorius. Now, according to the historian Zosimus, a great eclipse of the sun occurred during the progress of the battle; which he describes as follows: "*On the very occasion of the battle an eclipse of the sun occurred, such an eclipse that for a long time it was thought rather to be night.*" The date of that eclipse must have been A.D. 393 Nov. 20; since that was the only eclipse which was visible in that part of the world during the latter part of the reign of Theodosius. I find that it occurred about the middle of the day, and was total both at Rome and Constantinople. The shadow was more than one hundred miles in breadth, and the eclipse must have been very nearly total at the place where the battle was fought.*

Theodosius, therefore, died in January A.D. 394; and since Alaric invaded the Peloponnesus in the autumn of the same year, it follows that that invasion took place in the year A.D. 394. Now, Boetticher states in his work on "*Olympia*," that the last celebration of the Olympic games took place two years before that invasion; they therefore took place in the year A.D. 392, which was a leap year; and thus agrees with the other dates given by Boetticher for the celebration of those festivals; and also with all those which I have determined by means of eclipses.

I have now computed every well authenticated eclipse of antiquity which has come to my knowledge; and I have the satisfaction of finding a substantial and satisfactory agreement between the calculated and observed phases of such eclipses, in so far as the latter can be determined from the brief and imperfect historical notices that have been preserved concerning them. This agreement is all the more satisfactory, since it shows that the secular equations of the moon's motion, which I have computed and employed in these investigations must be substantially correct; and I shall now close these chronological investigations by a comparison of the places of the sun and moon as they are recorded for an epoch about five thousand years ago, with the places derived from computation by using the same values of the secular variations which have been employed in the computation of eclipses.

---

*According to the late Prof. G. Seyffarth the eclipse which took place at the time of the battle between Theodosius and Eugenius is also mentioned by Ammianus Marcellinus (Scal. p. 36; ed. Ronc. 271); and by Prosper Aquit. Chron. i, 672.

The epoch to which I refer is that of the *Calyougham*, which corresponds to midnight between Feb. 17 and 18 of the year B.C. 3102, at Benares in India. According to the *Surya Siddhanta* we have at that ancient epoch,

	°	′	″
Longitude of *Aldebaran*,	359	20	0
Longitude of the sun,	306	0	0
Mean longitude of the moon,	306	0	0
The greatest equations of the sun's center,	2	10	32
The obliquity of the ecliptic,	24	0	0

If we compute the value of the stellar and solar elements for that epoch by means of the secular variations of the elements as computed and tabulated in the writer's "*Memoir on the Secular Variations of the Orbits of the Eight Principal Planets*," and published as No. 232 of the *Smithsonian Contributions to Knowledge*, we shall find,

	° ′ ″	C—O ° ′ ″
Longitude of *Aldebaran*,	359 17 18.7	−0 2 41.3
True longitude of the sun,	303 38 51.5	−2 21 8.5
Greatest equation sun's center,	2 7 12	−0 3 20
The obliquity of the ecliptic,	24 3 25.2	+0 3 25.2

In order to bring into prominence the great importance of a correct value of the secular variation of the moon's mean motion, I have here given its value corresponding to my own formulas, and also the value as deduced from the formulas of LAPLACE and HANSEN; and I find secular variation of longitude,

	°	′	″
According to STOCKWELL,	5	1	8.4
" " LAPLACE,	6	19	4.8
" " HANSEN,	7	42	46.8

If we employ HANSEN's value of the moon's mean sidereal motion, together with the precession of the equinoxes as given by the writer in the work already mentioned, we shall find,

	Moon's Mean Long. ° ′ ″	Errors ° ′ ″
According to STOCKWELL,	306 4 43.1	0 4 43.1
" " LAPLACE,	307 22 39.5	1 22 39.5
" " HANSEN.	308 46 21.5	2 46 21.5

The error of LAPLACE's theory is here seen to be about eighteen times greater than the error of my own; while the error of HANSEN's theory is double that of LAPLACE. It thus appears that my value of the secular equation of the moon's longitude almost perfectly represents the moon's place as recorded for that ancient epoch; and also represents, with singular fidelity, all the well authenticated eclipses of antiquity. It is therefore little wonder that the late Sir GEORGE AIRY should lose confidence in the certainty of chronological deductions from a discussion of ancient eclipses by means of HANSEN's tables; since his value of the secular acceleration in longitude is so greatly erroneous that his tables fail to represent an eclipse of comparatively modern date; namely, the eclipse of A.D. 1140 March 20; which was total at London, according to the testimony of historians, whereas his tables would place the southern line of totality more than fifty geographical miles to the northward of that city. Prof. NEWCOMB also found such great discordances between the historical records of ancient eclipses and the calculated phases, that he despaired of reconciling them; and in his recent "*Researches on the Motion of the Moon*" he has ignored them altogether.

The above calculations show that the computed place of *Aldebaran* agrees almost perfectly with the recorded place of that star; and the same may be said of the mean longitude of the moon, of the equation of the sun's center, and of the obliquity of the ecliptic. But the computed place of the sun differs very considerably from its recorded place; the reason for which will be explained a little further on.

The question whether the elements of the planetary orbits as recorded for the epoch of the *Calyougham* were derived from observations made at that time, or were derived from modern observations, and reduced by calculation to that ancient epoch was a subject of interesting discussion about one hundred years ago. M. BAILLY, in a very elaborate and interesting history of the ancient astronomy of India, arrives at the extravagant conclusion that the places of the sun, moon, and planets at the epoch of the *Calyougham*, were derived from observations which were made in India during several thousand years antecedent to that epoch. His principal arguments for such a conclusion are based on the fact that there are no modern elements, with which the astronomers of India were acquainted, which, when corrected for all the known secular changes that must have taken place in the interval, would produce the elements recorded for that epoch. The views advanced by BAILLY were subsequently adopted and illustrated with great elegance and clearness by Prof. PLAYFAIR; who also derived some additional confirmations of BAILLY's theory from the investigations of LAPLACE.

The reason why BAILLY assumed that the observations on which the elements of the *Calyougham* epoch were based, were made some thousands of years earlier, was because the modern elements, when corrected for the secular changes arising from the action of the disturbing forces during a period of about five thousand years, did not quite agree with the recorded elements for that epoch; but the differences were of such a nature as to indicate that the observations were made at a much earlier epoch. For example, the obliquity of the ecliptic is given as 24° 0′; but if we compute the obliquity for that epoch, according to the formula of LAGRANGE, we should find that it was then equal to 23° 51′, instead of 24°; and it was thence inferred that if the calculation had been made for an epoch earlier by some *fifteen hundred* years we would obtain the value assigned for the epoch of the *Calyougham*. The same conclusion seemed also to be derived from similar considerations in regard to the greatest equation of the sun's center. But it must be remembered that the mathematicians of a hundred years ago had then only recently undertaken the calculation of the secular changes of the obliquity of the ecliptic; and it was subsequently shown by LAPLACE that the formula of LAGRANGE, which had been used by BAILLY for that purpose was quite erroneous. According to my own computation, the equation of the sun's center was equal to 2° 10′ 32″ in B.C. 5050, instead of B.C. 3102; and the obliquity of the ecliptic was equal to 24° 0′ in the year B.C. 2520, instead of B.C. 3102; so that one element would seem to correspond to a later, instead of an earlier date.

It would, therefore, appear that the recorded elements of the sun's orbit for the epoch of the *Calyougham* were only approximate rather than exact; but, on account of our ignorance of the means by which the approximate elements were determined, it is impossible to assign the limits of their possible errors. It is easy, however, to show that a skilful astronomer, under favorable conditions, might readily determine the obliquity of the ecliptic and the eccentricity of the the sun's apparent orbit, on which the equation of the center depends, with very considerable precision, in the course of a single year, without the aid of either optical or angular instruments of any description.

For, if we suppose an observer in an open field at station A to note the exact bearings of the sun when in the horizon at the time of the solstices; and denote these bearings by the lines AB and AC drawn towards the summer and winter solstices respectively; the angle included between these lines at the point A will denote the difference of the amplitudes of the sun when at the solstices, southern amplitudes being supposed negative. These lines when laid out may be called AB and AC; and if we measure a distance $AB = c$, $AC = b$, and $BC = a$; and call the amplitudes of these lines A and A', we shall have

$$\sin \tfrac{1}{2}(A-A') = \tfrac{1}{2}\sqrt{\frac{(a+b-c)(a-b+c)}{bc}} \tag{1}$$

If the $AB = AC$, we shall have $b = c$, and then equation (1) gives

$$\sin \tfrac{1}{2}(A-A') = \frac{a}{2b} \tag{2}$$

which gives the angular distance between the places of sunrise or sunset at the summer and winter solstices.

If we now denote the latitude of the place of observation by ϕ, the declination of the sun by δ, and the horizontal refraction by β, the amplitude of the sun when in the horizon will be given by the equation

$$\sin A = \frac{\sin\delta + \sin\phi\,\sin\beta}{\cos\phi\,\cos\beta} \tag{3}$$

and if we denote the obliquity of the ecliptic by ϵ, we shall have at the summer solstice $\delta = \epsilon$ and at the winter solstice $\delta = -\epsilon$; and equation (3) will give for these values of δ

$$\sin A = \frac{\sin\epsilon + \sin\phi\,\sin\beta}{\cos\phi\,\cos\beta} \tag{4}$$

$$\sin A' = \frac{-\sin\epsilon + \sin\phi\,\sin\beta}{\cos\phi\,\cos\beta} \tag{5}$$

These equations show that the sun's amplitudes would be equal, and have contrary signs at the solstices, if there were no refraction. But if we subtract equation (5) from (4) the refraction will be eliminated, and we shall find (6)

$$\sin A - \sin A' = 2\sin\tfrac{1}{2}(A-A')\cos\tfrac{1}{2}(A+A') = \frac{2\sin\epsilon}{\cos\phi\,\cos\beta}$$

This equation gives

$$\sin\epsilon = \sin\tfrac{1}{2}(A-A')\cos\phi\,\cos\beta\,\cos\tfrac{1}{2}(A+A') \tag{7}$$

and, if we neglect the square of the refraction, we may put $\cos\beta = 1$, also $\cos\tfrac{1}{2}(A+A') = 1$, and equation (7) will become

$$\sin\epsilon = \sin\tfrac{1}{2}(A-A')\cos\phi \tag{8}$$

This equation contains the two unknown quantities A and A', but since we only need the difference of those quantities, we have already found this by means of equation (2); and if we substitute that value of $\sin\tfrac{1}{2}(A-A')$ in equation (8) we shall get

$$\sin\epsilon = \frac{a}{2b}\cos\phi \tag{9}$$

If we now suppose the distances AB and AC to be, say 200 feet, and if we attach a circular disk to a pointed staff, the disk having an apparent diameter somewhat less than that of the sun as seen from the point A, we shall be able to bisect the sun's disk with very considerable accuracy. Then by measuring the third side of the triangle $BC = a$ we ought to be able to get the angle between the lines AB, AC, within 1′; and then equations (8) or (9) would give the obliquity of the ecliptic with a like degree of precision.

If we suppose the place of observation to be in latitude 20° north, and the horizontal refraction to be 36′, we shall have $\phi = 20°$, $\beta = 36'$. Then if we put the numerator of equation (3) equal to nothing, we shall have $\delta = -0°12'20''$; and hence a star whose declination is $-0°\ 12'\ 20''$, rises exactly in the prime vertical circle of 20° north latitude. If we put $\delta = 0°$, in equation (3) we find $A = +0°\,13'\,6''$; whence it follows that an equatorial star rises by that amount to the northward of the prime vertical. Again, if we take $\delta = \pm 24°\ 0'$, which was about the declination of the sun at the solstices at the epoch of the *Calyougham*, we shall find $A = +25°\ 53'\ 30''$, $A' = -25°\ 24'\ 25''$, instead of $\pm 25°\ 38'\ 50''$, which would be the value were there no refraction. We thus see that the refraction in amplitude is least for stars which rise in the prime vertical, and increases very nearly according to the same law for stars in north or south declination.

Strictly speaking, the horizon is not a convenient circle of reference for stars; for it is very seldom that any except the very brightest ones become visible until they are some degrees above the horizon; but for the sun it is both useful and convenient, especially during the infancy of astronomy. I have already explained how lines may be drawn with great precision towards the solstitial risings and settings of the sun; and if we bisect the angle included between those lines we shall have the directions of the equinoctial risings and settings of the sun, or the east and west points of the horizon, were it not for the effect of refraction, which we have seen would throw those points nearly one-quarter of a degree to the north. However, since the sun's daily motion in declination is very rapid at the time of the equinoxes, it would be a comparatively easy problem to determine with considerable precision, the length of the tropical year by merely noting the intervals between a few consecutive returns to such fixed points in the horizon. But unless the effect of refraction was known and allowed for the interval between the vernal and autumnal equinox would be at least a day longer than the interval between the autumnal and vernal; supposing of course that the sun's motion in longitude was uniform. And since the landmarks of the heavens are invisible when the sun is above the horizon, it would be a matter of some difficulty to transfer the place of the sun, when at the equinox, to its proper place among the stars. And therefore it is not strange that the sun's longitude should be given in the Indian Tables with much less precision than that of the moon and planets.

It would, perhaps, be easier to obtain essentially the same results by the use of a high gnomon; but my purpose has been to show how these elements of astronomy might be obtained without the use of instruments.

The eccentricity of the sun's apparent orbit may be obtained by two methods; neither of which requires a knowledge of the laws of elliptical motion, nor the use of angular instruments for measurements. The first of these methods consists in noting the interval of time required for the sun's disk to pass the meridian in the different parts of its orbit. If we note these intervals daily, and multiply them by the cosine of the sun's declination, we shall have a series of numbers which pass from a minimum to a maximum and the reverse, and which are inversely proportional to the sun's distance from the earth; and the quotient found by dividing the maximum of these numbers by the minimum, will be equal to unity plus twice the eccentricity of the sun's orbit.

The second method consists in measuring the actual length of the cone of shadow of a spherical ball, or of a circular disk, when the sun is at its greatest and least distances from the earth. If we suppose a circular disk, two feet in diameter, to be placed at such a distance from the eye as to just cover the sun when nearest to the earth; it would be necessary to place it about eight feet further from the eye in order to just cover it when farthest from the earth. We should, in this case, have a base of about eight feet, or ninety-six inches; and if these distances could be measured so closely as not to involve an error of more than one-tenth of a foot, their ratio would give the eccentricity so nearly correct that the sun's equation of the center would not be more than 2′ or 3′ in error.

We thus see that the astronomers of India had the means of determining the elements of the orbits of the sun and moon with all the precision those elements actually possess; and the hypothesis that several thousand years would be required in order to build up their rude system of astronomy seems to be without any logical foundation. It is true, however, that the mean motions which they assign to the planets *Jupiter* and *Saturn* are so nearly exact that several hundred years would seemingly be required in order to attain that degree of precision without the use of angular instruments; but, on the other hand, the errors in their determination of the length of the sidereal and tropical years are too great to allow us to suppose that they possessed any instruments of that character. We may, therefore, reasonably conclude that the places assigned by the astronomers of India to the several bodies to which I have called attention, are founded on observations which were made in India, near the epoch of the *Calyougham*; and that they possess a degree of precision that could only be attained by long and patient observation, supplemented by laborious calculations, which were based on correct theoretical knowledge in regard to the system of the world; and it is peculiarly gratifying to be able to find in the ancient literature of India, such valuable confirmations of the testimony of the numerous solar eclipses, in regard to the correctness of purely theoretical deductions of science, which were made five thousand years later.

Cleveland, Ohio, 1896 *January* 1.

NEW ELEMENTS OF THE ORBIT OF β416 = LAC. 7215.

By T. J. J. SEE.

Since Burnham's discovery of this rapid binary in 1876, the companion has described an arc of 280°. The magnitudes of the components are 6.4 and 7.8 respectively, and as the pair is never closer than 0″.58 the object is difficult only on account of its southern declination. The period is surprisingly short for a system of such considerable separation, and this circumstance lends decided probability to the view that the parallax is sensible. Provisional elements for this system have been computed by Glasenapp, Gore and Burnham. Their results are as follows:

P	T	e	a	☊	i	λ	Authority	Source
Years			″	°	°	°		
34.85	1892.00	0.65	1.52	104.3	45.4	300.7	Glasenapp, 1893	Astron. and Astroph., May 1893
34.48	1891.85	0.556	2.13	139.4	56.7	278.2	Gore, 1893	Monthly Notices, March 1893
24.7	1892.26	0.56	1.46	122.0	44.4	93.5	Burnham, 1893	Publ. Lick Obs. vol. II, p. 247

The observations which I recently secured at the Washburn observatory have enabled me to redetermine the orbit of this interesting star. Using all available measures, I find the following elements of $\beta 416$:

P = 33.0 years
T = 1891.85
e = 0.512
a = 1″.2212

☊ = 144°.6
i = 37°.35
λ = 86°.1
n = −9°.0908

Apparent orbit:

Length of major axis = 2″.76
Length of minor axis = 2″.38
Angle of major axis = 142°.5
Angle of periastron = 59°.5
Distance of star from center = 0″.61

COMPARISON OF COMPUTED WITH OBSERVED PLACES.

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o - \theta_c$	$\rho_o - \rho_c$	n	Observers
	°	°	″	″	°	″		
1876.52	240. ±	233.4	1.8 ±	1.79	+6.6	+0.01	1	Burnham
1877.53	222.6	228.2	1.80	1.79	−5.4	+0.01	1	Cincinnati
1877.64	224.4	227.6	1.77	1.78	−3.2	−0.01	1	Russell
1888.72	147.5	147.7	1.88	1.19	−0.2	+0.69	1	Burnham
1889.43	135.2	136.7	1.17	1.04	−1.5	+0.13	2–1	Burnham
1889.63	131.9	133.1	0.97	1.00	−1.2	−0.03	1	Pollock
1891.53	81.2	75.2	0.53	0.60	+6.1	−0.07	3–2	Burnham
1892.38	24.4	34.0	0.61	0.61	−9.6	0.00	4–3	Burnham
1894.57	330.8	333.6	0.94	1.10	−2.8	−0.16	7–2	Sellors
1895.60	321.7	319.9	0.91	1.30	+1.8	−0.39	2–1	Comstock
1895.74	320.0	318.4	1.30 ±	1.32	+1.6	−0.02	1	See

The angular motion during the last three years has not been very rapid, and the constancy of areas shows that the distances have been somewhat undermeasured. It is now apparent that the period will be sensibly longer than BURNHAM supposed. The value found above is not likely to be in error by more than one year, while the correction of the eccentricity will hardly exceed ±0.03. Considering the small number of observations on which this orbit is based, the elements may be regarded as highly satisfactory. As this system is visible in the United States, it is worthy of particular attention from American observers. The coordinates for 1900.0 are:

$$\alpha = 17^{\text{h}}\ 12^{\text{m}}.1\ ; \quad \delta = -34^\circ\ 52'$$

The following ephemeris gives the place of the companion for five years:

t	θ_c	ρ_c
	°	″
1896.50	310.6	1.43
1897.50	302.1	1.54
1898.50	294.6	1.62
1899.50	287.7	1.69
1900.50	281.5	1.72

The University of Chicago, 1895 *Dec.* 16.

NOTES ON VARIABLE STARS,—No. 12,

BY HENRY M. PARKHURST.

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date		E	Corr.	W	Remarks
			Julian	Calendar				
				1895				
7431	*S Delphini*	Max.	3443	Sept. 6	39	0	9	
7455	*U Capricorni*	Max.	3525	Nov. 27	69	−21	7	Agrees with the result of the two previous years
7458	*V Delphini*	–	–	–	–	–	–	Periodicity not yet certain
7468	*T Aquarii*	Max.	3496.1	Oct. 29	61	− 1	9	Repeated fluctuations
7492	*RZ Cygni*	–	–	–	–	–	–	Period probably more than a year
7560	*R Vulpeculae*	Max.	3455.2	Sept. 18	80	− 7	9	
"	"	Min.	3535:	Dec. 7	81	− 2	1	Estimation independent of prediction
7577	*X Capricorni*	Max.	3449	Sept. 12	47	+ 2	9	Interruption from moon for 16 days

No.	Star	Phase	Observed Date		E	Corr.	W	Remarks
			Julian	Calendar				
				1895-6				
7590	*Z Capricorni*	Max.	3526	Nov. 28	–	–	6	Suggested period 181 days
7733	*Y Capricorni*	Max.	3488	Oct. 21	18	–10	6	Double period not yet tested
7909	*S Pisc. Austrini*	Max.	3516	Nov. 18	7	– 8	9	
7994	*R Pisc. Austrini*			–	–	–	–	Maximum approaching in December
8068	*S Lacertae*	Min.	3461	Sept. 24	3	+ 7	6	Compared with my elements in *A.J.* 339
..	..	Max.	3565.9	Jan. 6	3	+ 5	9	Compared with my elements in *A.J.* 339
(8104)	*— Aquarii*	–		–	–	–	–	No material change observed in three years
(8106)	*— Pegasi*	–	–	–	–	–	–	No material change observed in three years
8230	*S Aquarii*	Max.	3537	Dec. 9	47	– 4	9	
8373	*S Pegasi*	Min.	3507	Nov. 9	36	+10	8	Assuming $M-m$ as in *A.J.* 346
8598	*U Pegasi*	Min.	3481.65	Oct. 14	1683	–		Confirms variation, period 2.07; See *A.J.* 358
..	..	Min.	3488.546	21	1713	–0.002	8	Confirms period of 0.69 days
..	..	Min.	3502.584	Nov. 4	1774	+0.006	6	Confirms period of 0.23 days
8600	*R Cassiopeae*	Max.	3449.4	Sept. 12	35	+22	9	
8622	*W Ceti*	–	–	–	–	–	–	Not seen, October–January: *A.J.* 342 and 347

INDIVIDUAL OBSERVATIONS.

7431 *S Delphini.*

Julian	Calendar	Mag.
	1895	M
3423.6	Aug. 17	10.13_2
3429.6	23	10.25_2
3431.5	25	10.27_2
3442.5	Sept. 5	9.83_2
3445.6	8	9.37_2
3448.6	11	10.15_2
3449.6	12	10.16
3450.5	13	9.35_2
3451.5	14	9.58_2

7455 *U Capricorni.*

(Continued from 339)

Julian	Calendar	Mag.
	1895	
3449.6	Sept. 12	12.3]
3490.6	Oct. 23	12.0]
3503.5	Nov. 5	12.0]
3509.5	11	11.80_2
3516.5	18	11.44_2
3519.5	21	11.03_2
3521.5	23	10.97_2
3532.5	Dec. 4	11.43_2
3534.5	6	11.54

7458 *V Delphini.*

(Continued from 339)

Julian	Calendar	Mag.
	1895-6	
3423.6	Aug. 17	12.9
3424.6	18	12.88_2
3447.6	Sept. 10	13.4
3455.6	18 to	
3574.5	Jan. 15	13.2]
	7 dates	

7468 *T Aquarii.*

(Continued from 339)

Julian	Calendar	Mag.
	1895	
3424.5	Aug. 18	12.0
3455.5	Sept. 18	9.55_2
3467.6	30	8.67_2
3474.5	Oct. 7	7.73_2
3481.5	14	7.45_2
3487.5	20	7.60_2
3491.5	24	7.26_2

7468 *T Aquarii.*—Cont.

Julian	Calendar	Mag.
	1895	M
3492.5	Oct. 25	6.91_2
3495.5	28	7.48_2
3496.5	29	6.89_2
3497.5	30	7.35_2
3499.5	Nov. 1	6.98_2
3501.5	3	7.87_2

7492 *RZ Cygni.*

Julian	Calendar	Mag.
	1894-6	
2988	June 8 to	
3152	Nov. 19	11.5]
	6 dates	
3183	Dec. 20	11.5
3209	Jan. 15	11.0
3213	19	11.0
3221	27	10.8
3386	July 11 to	
3574	Jan. 15	11.5]:
	14 dates	

7560 *R Vulpeculae.*

(Continued from 311)

Julian	Calendar	Mag.
	1895-6	
3421.6	Aug. 15	10.6
3427.6	21	9.76_2
3434.6	28	9.01_2
3445.6	Sept. 8	8.29_2
3450.6	13	8.57_2
3454.5	17	7.90_2
3456.6	19	7.80_2
3459.6	22	8.57_2
3460.6	23	8.21_2
3464.6	27	8.13_2
3467.6	30	8.62_2
3488.5	Oct. 21	10.76_2
3509.5	Nov. 11	12.9]
3561.5	Jan. 2	11.33_2

7577 *X Capricorni.*

(Continued from 311)

Julian	Calendar	Mag.
	1895	
3424.6	Aug. 18	11.45_2
3425.6	19	11.53_2

7577 *X Capri.*—Cont.

Julian	Calendar	Mag.
	1895	M
3429.6	Aug. 23	11.44_2
3445.5	Sept. 8	11.12
3450.6	13	11.17_2
3451.6	14	11.04_2
3452.6	15	11.06_2
3454.6	17	11.27_2
3455.6	18	11.20_2
3459.6	22	11.32_2

7590 *Z Capricorni.*

Julian	Calendar	Mag.
	1895	
3513.5	Nov. 15	9.87_2
3514.5	16	10.16_2
3517.5	19	9.99_2
3519.5	21	10.16_2
3525.5	27	9.78_2
3533.5	Dec. 5	10.09_2
3539.5	11	10.54_2

7733 *Y Capricorni.*

(Continued from 339)

Julian	Calendar	Mag.
	1895	
3425.5	Aug. 19	12.5]
3449.6	Sept. 12	12.5]
3459.6	22	12.5]
3475.5	Oct. 8	11.6
3477.6	10	12.08_2
3484.6	17	11.56_2
3488.6	21	11.52_2
3502.5	Nov. 4	12.30_2
3508.6	10	12.45

7909 *S Piscis Austrini.*

Julian	Calendar	Mag.
	1894-5	
3121.6	Oct. 19 to	
3178.5	Dec. 15	11.0]
	4 dates	
3485.6	Oct. 18	9.6
3487.6	20	10.13
3490.6	23	9.66_2
3507.5	Nov. 9	9.37
3509.5	11	8.88_2

7909 *S Pisc. Austr.*—Cont.

Julian	Calendar	Mag.
	1895	M
3516.5	Nov. 18	8.20_2
3520.5	22	8.72_2
3525.5	27	8.99_2
3532.5	Dec. 4	9.13_2
3539.5	11	9.3
3542.5	14	9.29_2

7994 *R Piscis Austrini.*

Julian	Calendar	Mag.
	1894-5	
3121.6	Oct. 19 to	
3178.5	Dec. 15	11.7]
	4 dates	
3485.6	Oct. 18	11.3]
3507.5	Nov. 9	12.05
3516.5	18	11.27_2
3532.5	Dec. 4	9.57_2
3539.5	11	9.0
3542.5	14	8.87_2

8068 *S Lacertae.*

(Continued from 339)

Julian	Calendar	Mag.
	1895-6	
3423.6	Aug. 17	11.7
3427.6	21	11.6
3428.6	22	12.31_2
3431.6	25	12.41_2
3447.6	Sept. 10	12.7
3460.5	23	12.73_2
3475.5	Oct. 8	12.6]
3485.5	18	12.57_2
3490.6	23	12.42
3516.5	Nov. 18	11.2
3533.5	Dec. 5	10.20_2
3543.5	15	9.70_2
3559.5	31	7.83_2
3560.5	Jan. 1	7.83_2
3561.5	2	7.89_2
3571.5	12	7.69_2
3577.5	18	8.07_2
3587.5	28	8.24_2
3600.5	Feb. 10	9.16_2

(8104) *F Aquarii.*

Julian	Calendar	Mag.
	1893-5	M
2694	Aug. 18 to	
2843	Jan. 14	11
3064	Aug. 23 to	
3211	Jan. 17	11
3421	Aug. 15 to	
3543	Dec. 15	11
	19 dates	

(8106) *— Pegasi.*

Julian	Calendar	Mag.
	1893-6	
2694	Aug. 18 to	
2860	Jan. 31	13
3064	Aug. 23 to	
3211	Jan. 17	13
3421	Aug. 15 to	
3574	Jan. 15	13
	19 dates	

8230 *S Aquarii.*

(Continued from 346)

Julian	Calendar	Mag.
	1895	
3491.6	Oct. 24	11.4]
3510.5	Nov. 12	10
3513.6	15	9.1
3516.6	18	9.88
3525.5	27	8.89_2
3531.5	Dec. 3	9.10_2
3539.6	11	8.44_2
3542.5	14	8.42_2
3544.5	16	8.86_2
3555.5	27	9.12_2
3559.5	31	9.07_2

8373 *S Pegasi.*

(Continued from 346)

Julian	Calendar	Mag.
	1895	
3447.6	Sept. 10	12.0
3459.6	22	13.0
3460.5	23	12.76_2
3475.5	Oct. 8	12.4
3477.6	10	12.88_2
3484.6	17	12.61_2
3490.6	23	12.92

8373 *S Pegasi.*—Cont.

Julian	Calendar	Mag.
	1895	M
3508.6	Nov. 10	13.01_2
3516.5	18	12.63_2
3519.6	21	12.48_2
3540.6	Dec. 12	12.23_2

8598 *U Pegasi.*

Julian	Calendar	Mag.
	1895	
3481.497	Oct. 14	9.88
.512		9.87
.546		10.07

8598 *U Pegasi.*—Cont.

Julian	Calendar	Mag.
	1895	M
3481.566	Oct. 11	10.21
.586		10.14
.605		10.50
.613		10.40
.624		10.77
3488.465	Oct. 21	9.57_2
.510		10.03_2
.515		10.20_2
.522		10.37_2

8598 *U Pegasi.*—Cont.

Julian	Calendar	Mag.
	1895	M
3488.531	Oct. 21	10.24_2
.538		10.51_2
.547		10.58_2
.554		10.47_2
.561		10.43_2
3502.517	Nov. 4	10.45_2
.543		10.05_2
.568		10.36_2
.587		10.94_2

8598 *U Pegasi.*—Cont.

Julian	Calendar	Mag.
	1895	M
3502.594	Nov. 4	10.56_2
.608		10.50_2

8600 *R Cassiopeae.*
(Continued from 346)

Julian	Calendar	Mag.
	1895	
3424.6	Aug. 18	9.18_3
3431.6	25	8.46_2
3434.6	28	7.77_2
3442.6	Sept. 5	7.08_2
3447.6	10	6.84_2

8600 *R Cassiop.*—Cont.

Julian	Calendar	Mag.
	1895	M
3450.6	Sept. 13	6.59_2
3451.5	14	6.96_2
3452.6	15	6.79_2
3454.5	17	7.04_2
3456.6	19	7.02_2

8622 *W Ceti.*

Julian	Calendar	Mag.
	1895-6	
3485.6	Oct. 18 to	
3561.5	Jan. 2	12]

4 dates

Comparison-Stars.

7590 *Z Capricorni.*

Star	DM.	Mag.	*n*
N	−16°5804	8.90	4
1*N*	−16°5816	8.41	3
T	−16°5815	9.66	7
W	−16°5803	10.38	5
X	−16°5809	10.51	8
Y	−16°5812	11.50	2
Z	−16°5813	11.99	1

7909 *S Piscis Austrini.*

Star	C.DM.	Mag.	*n*
F	−28°17533	7.15	4*M*
G	−28°17605	7.30	3
I	−28°17604	7.83	2
M	−28°17592	8.34	8
N	−28°17554	8.42	4
P	−28°17587	8.68	9
1*P*	−28°17537	8.65	2
2*P*	−28°17600	9.11	12
T	−28°17558	9.29	6
U	−28°17568	9.77	3
X	−28°17573	11.06	1

7994 *R Piscis Austrini.*

Star	C.DM.	Mag.	*n*
P	−30°19081	9.28	4
1*P*	−30°19073	9.01	1*M*
Q	−30°19062	9.07	0*M*
R	−30°19102	8.78	1
1*R*	−30°19054	9.17	0*M*
S	−29°18287	9.87	0*M*
T	−30°19094	9.79	2
1*T*	−29°18274	9.53	4*M*
U	−29°18270	9.93	4*M*
1*U*	−29°18284	10.12	0*M*
W	−30°19096	11	0

7994 *R Pisc. Austrini.*—Cont.

Star	C.DM.	Mag.	*n*
1*X*	−30°19085	12 :	0
Y	−30°19088	11.27	2
1*Y*	−30°19089	11.30	4
Z	−30°19087	11.70	2

8598 *U Pegasi.*

Star	C.DM.	Mag.	*n*
H	+14°5077	8.02	2*M*
K	+15°4903	8.41	2*M*
R	+15°4916	9.33	2
3*Z*	+15°4912	10.72	4
a	27*np* 3*Z*	11.01	4

OBSERVATIONS OF COMET *a* 1896,

MADE WITH THE 6.2-INCH REFLECTOR AND FILAR MICROMETER,

BY J. A. PARKHURST.

1896 Central Stand. Time		∗	No. Comp.	☄ − ∗		☄'s apparent		log *p*Δ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
March 2	7 5	1	6	. . .	− 9 33.9	. . .	+51 33 24.6	. .	0.438
	7 18 53	1	4	+1 11.42	. . .	0 47 55.76	. . .	9.840	. .
3	7 10	2	10	. . .	− 4 51.8	. . .	+51 46 3.9	. .	0.387
	7 20 45	2	3	+0 29.09	. . .	1 9 27.13	. . .	9.837	. .
4	7 6	3	10	. . .	+ 6 9.1	. . .	+51 44 18.3	. .	0.284
	7 18 21	3	4	−0 25.81	. . .	1 28 40.79	. . .	9.823	. .
7	7 10 30	4	7	. . .	+ 0 52.5	. . .	+50 49 55.5	. .	0.143
	7 21 30	5	1	−0 17.19	. . .	2 14 27.18	. . .	9.788	. .
8	7 14	6	6	. . .	−20 32.4	. . .	+50 23 42.9	. .	0.134
	7 27 31	6	4	−1 42.09	. . .	2 26 25.47	. . .	9.780	. .
11	7 13 10	7	7	. . .	+ 0 40.8	. . .	+49 0 58.8	. .	0.074
	7 23 5	7	6	−1 54.61	. . .	2 54 49.70	. . .	9.748	. .
12	8 2 8	8	5	. . .	+17 50.2	. . .	+48 31 45.4	. .	0.330
	8 13 7	8	5	+0 19.44	. . .	3 2 40.51	. . .	9.789	. .

Mean Places for 1896.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 46 45.67	−1.33	+51 42 47.5	+11.0	½ (Rogers, Cambr. A.G. Catal. 378 + Paris)
2	1 8 59.21	−1.17	+51 50 43.0	+12.6	Rogers, Cambr. A.G. Catal. 566 [+2 Paris)
3	1 29 7.60	−1.00	+51 37 55.2	+13.9	⅕ (2 Rogers. Cambr. A.G. Catal. 709 + Argel. 1842
4	2 14 32.44	−0.55	+50 48 46.8	+16.2	⅓ (2 Rogers, Cambr. A.G. Catal. 1096 + Bonn VI)
5	2 14 44.93	−0.55	+50 58 54.5	+16.3	⅓ (2 Rogers, Cambr. A.G. Catal. 1099 + Bonn VI)
6	2 28 7.97	−0.42	+50 43 58.5	+16 8	⅓ (2 Rogers, Cambr. A.G. Catal. 1195 + Bonn VI)
7	2 56 44.42	−0.12	+48 59 0.7	+17.3	Deichmüller, Bonn A.G. Catal. 2574
8	3 2 21.17	−0.07	+48 13 38.0	+17.2	⅓ (2 " Bonn A.G. Catal. 2640 + Bonn VI)

Position of observatory: Longitude, $5^h\ 54^m\ 25^s.18$ from Greenwich , Latitude, +42° 14′ 51″.5.

Marengo, Illinois, 1896 *March* 31.

OBSERVATIONS OF COMET 1895 II (*a* 1895),

MADE AT THE LICK OBSERVATORY, WITH THE 36-INCH EQUATORIAL,

BY W. W. CAMPBELL AND W. J. HUSSEY.

1896 Mt. Hamilton M.T.		✱	No. Comp.	☄ — ✱		☄'s apparent		log *p*Δ		Obs.
				Δα	Δδ	α	δ	for α	for δ	
	h m s			m s	′ ″	h m s	° ′ ″			
Jan. 3	8 24 54	25	*d*3 , 2	+0 11.18	+0 35.2	2 17 0.77	+ 9 27 23.7	9.097	0.618	C
4	6 49 24	27	*d*7 . 4	−0 5.75	+0 26.4	2 18 8.91	+ 9 31 42.4	*n*8.820	0.614	C
	9 14 18	27	*d*7 . 5	+0 1.30	+1 14.7	2 18 15.96	+ 9 35 30.7	9.354	0.627	C
	9 46 13	28	*d*5	+0 9.02	. . .	2 18 17.36	. . .	9.448	. .	H
6	7 44 24	29	*d*7 . 7	+0 2.53	−0 44.3	2 20 38.83	+ 9 50 51.4	8.771	0.610	C
	9 9 54	29	*d*5 . 10	+0 6.85	−0 21.0	2 20 43.15	+ 9 51 14.7	9.360	0.624	H
	9 44 49	29	*d*6	+0 8.70	. . .	2 20 45.00	. . .	9.461	. .	C
8	7 15 41	31	4	. . .	+0 38.1	. . .	+10 6 30.1	. .	0.605	H
	8 25 54	31	*d*7 , 6	−0 3.28	+0 58.2	2 23 11.00	+10 6 50.2	9.188	0.612	C
	8 41 58	31	*d*5	−0 2.59	. . .	2 23 11.69	. . .	9.267	. .	H
9	10 36 48	33	*d*4 , 4	−0 6.92	−0 33.4	2 24 53.18	+10 15 24.7	9.576	0.651	C
31	6 52 38	35	2	. . .	+0 9.9	. . .	+13 4 32.8	. .	0.561	C
Feb. 2	9 15 27	37	*d*6	−0 5.37	. . .	2 57 1.70	. . .	9.568	. .	C
	9 38 28	37	*d*3	−0 4.51	. . .	2 57 2.56	. . .	9.586	. .	H
5	7 21 49	39	5	. . .	+1 49.7	. . .	+13 41 49.0	. .	0.560	H
	8 34 4	39	*d*4 , 3	−0 7.70	+2 3.1	3 1 18.21	+13 42 2.4	9.486	0.590	C

Mean Places for 1896.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
25	2 16 48.64	+0.95	+ 9 26 40.2	+8.3	11ᴹ ±, connected with ✱26
26	2 15 19.53	+0.94	+ 9 31 46.9	+8.3	DM. 9°306, merid.-circ. determination by Tucker
27	2 18 13.72	+0.91	+ 9 34 7.7	+8.3	13ᴹ ±, connected with ✱26
28	2 18 7.40	+0.94	+ 9 36 ±	+8.3	14ᴹ ±, connected with ✱27
29	2 20 35.38	+0.92	+ 9 51 27.4	+8.3	12ᴹ ±, connected with ✱30 [+Rumk. 2ʰ611)
30	2 18 36.24	+0.92	+ 9 48 2.7	+8.3	$\frac{1}{7}$ (2 Glasgow 531 + 2 Paris$_3$ 2975 + 2 Schj. 681–2
31	2 23 13.36	+0.92	+10 5 13.7	+8.3	14ᴹ ±, connected with ✱32
32	2 21 10.80	+0.90	+10 5 50.3	+8.2	$\frac{1}{3}$ (Gr. 9-yr. 221 + Paris 3035 + Y. 1118)
33	2 24 39.18	+0.92	+10 15 49.8	+8.3	13ᴹ ±, connected with ✱34
34	2 20 36.00	+0.90	+10 10 31.3	+8.2	Porter's proper-motion stars 170
35	2 53 57.37	+0.85	+13 4 14.3	+8.6	12ᴹ ±, connected with ✱36
36	2 56 41.41	+0.87	+13 2 40.7	+8.6	Schjellerup 855
37	2 57 6.24	+0.83	+13 18 45.7	+8.6	15ᴹ ±, connected with ✱38
38	3 0 6.64	+0.85	+13 18 11.6	+8.6	Schjellerup 870
39	3 1 25.10	+0.81	+13 39 50.8	+8.5	13ᴹ, connected with ✱40
40	3 6 30.67	+0.84	+13 38 51.9	+8.6	Weisse's Bessel III, 53

NOTES.

Professor TUCKER kindly determined the position of ✱26 with the meridian circle.

d indicates that the right-ascensions were measured directly with the micrometer.

The observations made between Jan. 3 and Jan. 9 were somewhat difficult; those made between Jan. 31 and Feb. 5 were extremely difficult. The sky was not in first-class condition on any of the February dates.

The theoretical brightness of the comet on February 5 was 0.010 of that at discovery.

Mt. Hamilton, Cal., 1896 *March* 28.

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PUBLISHED IN BOSTON, TRI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed April* 14.

THE

ASTRONOMICAL JOURNAL.

No. 373.

VOL. XVI. BOSTON, 1896 APRIL 30. NO. 13

ORBIT OF *RS SAGITTARII*, CH. 6546,

By ALEX. W. ROBERTS.

I purpose, in the present paper, dealing with the orbital elements of *RS Sagittarii* as obtained from observations made at Lovedale during 1895.

I have already (*Astr. Journ.*, No. 349) given the chief elements of variation, as determined from observations made during April and May 1895. These elements will require some slight modification, and as the orbital elements depend entirely upon the light-curve, it is necessary, in the first place, to determine the form of the light-curve with all possible accuracy.

The observations throughout the year were made with a one-inch transit glass. Each separate observation is the mean of two observations, taken at the same time, one direct, and the other reverse. This method of observation reduces to a minimum the error arising from the position of the variable with respect to the comparison-stars.

In determining the magnitude of *RS Sagittarii* the following twelve comparison-stars were employed.

Lacaille	R.A. 1900	Decl. 1900	Estimated Mag.	U.A. Mag.
	h m s	° ′ ″	M	M
7588	18 3 27	−32 43 53	7.28	7.0
7592	18 4 18	33 49 9	6.65	6.5
7629	18 8 47	34 37 26	7.54	
7632	18 9 6	33 7 17	7.69	
7651	18 11 16	33 25 51	7.66	
7657	18 11 51	34 43 23	7.61	
7661	18 13 34	35 28 11	7.42	
7669	18 14 21	33 22 1	7.67	
7684	18 16 43	36 17 14	7.30*	6.2
7695	18 18 38	36 2 45	6.88	6.7
7701	18 19 18	34 0 2	6.92	6.8
7708	18 20 38	−36 4 28	7.35	

* So in original.

The magnitudes both of the comparison-stars and the variable were determined by the method of sequences, the reference-magnitude being $6^M.8$, the magnitude of a star just visible and no more.

This may seem rather an uncertain starting point, but in my own experience the uncertainty has not been so great as to destroy confidence in the absolute values of the magnitudes so determined. Indeed, it is possible that no more definite standard can be obtained than this simple natural limit. At the same place, and under the same conditions of observing, it can probably be relied on to less than one-tenth of a magnitude.

The magnitudes of the comparison-stars, given in the preceding table, are the mean values obtained from combining all the measurements made.

It is of some interest to note the constant difference between the Lovedale and U.A. values. Thus

L. 7588 R.−G. = $+0^M.28$
L. 7592 = +0.15
L. 7684 = +0.10
L. 7695 = +0.18
L. 7701 = +0.12

It would appear from this that my estimate of the magnitude of stars near the seventh magnitude is, on the average, $0^M.17$ lower than that of the Cordoba observers, a result caused by the poor seeing conditions of this part of South Africa. Sometimes, for weeks, there is a thick haze overhead, making observations of any kind an impossibility.

Lac. 7592, used as a comparison-star, is certainly variable between the limits $6^M.5$ and $6^M.8$.

The uncertain and irregular variation of this star has given me no small trouble in completing the necessary reductions to standard values.

The detailed observations are given in the following table. The time of observation is Cape mean time, corrected of course for the velocity of light. If Greenwich mean time is required, 1½ hours will have to be subtracted from the given dates.

It may not be out of place to remark here that in securing observations I have always considered the actual determination of the minimum phase as being of secondary importance to the securing of observations all along the light-curve.

Detailed Observations.

Cape M.T.			Mag.	Cape M.T.			Mag.	Cape M.T.			Mag.	Cape M.T.			Mag.
1895	h	m	M	1895	h	m	M	1895	h	m	M	1895	h	m	M
April 19	11	31	6.50	May 20	10	23	6.93	June 18	8	31	6.70	Sept. 14	8	7	6.60
22	10	19	6.55		10	49	6.98		9	45	6.85		9	7	6.60
26	9	53	7.65		11	9	7.03		10	29	6.90		9	32	6.60
	10	39	7.48		11	29	7.05	20	7	49	6.60		9	52	6.60
	11	25	7.40		11	45	7.10	25	7	26	6.60	16	8	22	6.50
	11	51	7.13		12	25	7.22	27	9	45	6.65	Oct. 10	7	28	6.60
	12	35	7.10		13	2	7.41	July 15	7	23	6.75		7	46	6.60
	12	55	7.00		13	15	7.50	16	6	51	6.90		8	23	6.50
27	9	20	6.55		13	32	7.50		7	22	6.80		8	46	6.55
	10	55	6.60		13	47	7.45		7	43	6.85		9	18	6.52
29	9	35	6.70		14	17	7.45		7	56	6.80		9	38	6.60
30	11	30	6.50		14	37	7.28		8	21	6.80		10	8	6.60
	11	35	6.50		16	45	6.85		8	41	6.78		10	37	6.60
May 1	8	35	7.25	21	7	40	6.65		8	58	6.81		11	18	6.65
	9	5	6.90		8	19	6.60		9	16	6.82	11	6	53	6.98
	10	5	6.75		8	47	6.60	21	7	0	6.55		7	8	6.90
	12	37	6.55		9	31	6.60	22	8	4	7.43		7	18	6.90
2	9	50	6.82		9	47	6.55		8	17	7.43		7	25	6.82
	10	25	6.85	23	7	17	6.65		8	28	7.50		7	35	6.90
	11	0	6.82		7	47	6.60		8	50	7.60		7	48	6.86
	12	35	6.75	26	7	6	6.60		8	55	7.62		8	3	6.83
	14	50	6.55		8	28	6.60		9	13	7.60		8	22	6.87
3	9	5	6.62		10	12	6.55		9	29	7.45		8	38	6.83
	9	35	6.68		10	29	6.60		9	33	7.53		8	53	6.82
	10	10	6.65		10	43	6.60		9	43	7.48		9	3	6.74
	10	15	6.65	27	7	50	6.60		10	47	7.29		9	18	6.73
	10	40	6.70		9	4	6.60		11	11	7.15		9	43	6.70
6	9	0	6.70		9	50	6.65	25	7	47	6.65		10	24	6.65
14	8	52	6.60	28	7	36	6.60	Aug. 9	7	36	6.68		10	43	6.55
15	7	57	6.60		8	38	6.60	14	6	35	6.70		11	3	6.65
	9	37	6.75		9	10	6.60		7	35	6.90	12	7	52	6.65
	11	12	6.65		11	0	6.60		8	10	6.90		8	13	6.80
16	8	2	6.70	29	7	3	6.60		8	40	6.80		8	48	6.75
	9	37	6.65		8	3	6.60		9	15	6.65		10	8	*6.70
	10	57	6.65		9	58	6.60		9	35	6.60	17	6	52	7.35
	11	50	6.65	30	8	48	6.92	15	7	5	6.65		7	8	7.42
17	7	42	6.65		9	28	6.82		8	0	6.80		7	17	7.45
	8	7	6 60	31	7	36	6.78		8	28	6.65		7	39	7.48
	8	37	6.60		7	40	6.70		9	35	6.85		7	44	7.48
	9	7	6.60		8	17	6.90		10	15	7.05		7	50	7.55
18	7	18	7.00		8	32	6.92		10	53	7.15		8	9	7.56
	7	14	6.95		8	47	6.85		11	16	7.35		8	20	7.55
	8	31	6.70		9	7	6.85		11	36	7.40		8	28	7 55
	8	54	6.67		9	47	6.90		11	48	7.42		8	41	7.54
	9	14	6.70		10	2	6.85		11	53	7.48		8	58	7.50
	9	51	6.65		10	27	6.85		12	12	7.48		9	24	7.40
	10	46	6.65		10	56	6.90		12	33	7.58		9	40	7.30
19	7	23	6.83		11	56	6.80		12	48	7.55		10	2	7.15
	7	47	6.80		12	45	6.83		13	3	7.60		10	17	7.15
	8	31	6.90		13	25	6.83		13	17	7.58		10	32	7.15
	8	51	6.95		13	35	6.71		13	32	7.55	23	7	41	6.83
	9	15	6.88	June 10	8	38	6.60		13	48	7.50		7	51	6.88
	10	16	6.75	11	6	3	7.51		14	2	7.50		8	6	6.88
	10	42	6.70		6	43	7.50	20	6	45	7.05		8	21	6.90
	11	22	6.65		7	3	7.53		7	10	7.27		8	31	6.92
	15	1	6.55		7	48	7.49		7	45	7.48		8	56	6.90
20	7	32	6.70		7	53	7.45		8	5	7.48		9	4	6.83
	8	3	6.70		8	24	7.35		8	20	7.52		9	26	6.83
	8	43	6.68		8	28	7.38		8	35	7.46		9	41	6.80
	9	29	6.70	13	7	19	6.50		8	50	7.53		10	11	6.75
	9	52	6.80	15	7	26	6.60	Sept. 13	7	42	6.60	23	10	26	6.80
	10	17	6.85	17	8	38	6.90		8	42	6.85				

* Low down and difficult to observe. Night hazy.

These observations yield a mean period of $2^d\ 9^h\ 58^m.8$. With this period all the observations were reduced to the light-variation of May 20–22. In this way a well defined light-curve was obtained. The chief elements of the curve are as follows:

Total period	$2^d\ 9^h\ 58^m.8$
Duration of constant period	$37^h\ 9^m$
Duration of chief minimum phase	$12^h\ 50^m$
Duration of secondary minimum phase	$8^h\ 0^m$
Magnitude at constant period	$6^M.60$
Magnitude at chief minimum	$7^M.59$
Magnitude at secondary minimum	$6^M.89$
Epoch of chief min. phase	1895 May 20 $12^h\ 5^m$ G.M.T.
Epoch of secondary min. phase	May 21 $16^h\ 50^m$

In determining the orbital movement of *RS Sagittarii* from its light-curve, we are met, at the very outset of our inquiry, with the important question of the true value of the "light-ratio."

It is to be hoped that a new determination of this important constant will be undertaken by those who have the necessary aids and experience. Indeed, such a determination is imperative, if investigations dealing with orbital motion as deduced from light-variation are to be of real scientific interest.

It may be urged that the accepted value, 2.512, is accurate enough for all purposes connected with stellar variation. This I doubt, and mainly because my own investigations would seem to indicate that the "light-ratio" is not a constant quantity, but varies with the magnitudes under consideration. Thus, two third-magnitude stars will, when combined, yield the light of a second-magnitude star, but it takes more than three ninth-magnitude stars to equal an eighth.

The investigations to which I refer were carried out in the month of October, my instrumental accessories being simply a sextant on an altazimuth stand. The magnitudes of certain stars seen directly through the horizon-glass were estimated, then one or more stars were brought into the field by means of the under mirror, and their magnitudes estimated. A slow movement of the sextant enabled me to superimpose any two stars; and the increase in brightness was determined by comparison with the other stars in the field.

The resulting expression for the light-ratio from this investigation was

$$L = 2.60 + 0.20\,(M - 6^M.0)$$

A fuller investigation of the matter has always been a present desire with me, but hitherto I have only been able to deal with it partially; notwithstanding the meagreness of the data on which the preceding value of L is based, I am convinced that it is not far from the truth.

Returning now to the investigation of the light-changes of *RS Sagittarii* we notice, first, that the duration of the chief minimum phase is one and a half times longer than the duration of secondary minimum; the orbit is accordingly eccentric. Second, the combined light of both stars during the constant period is $6^M.60$; at chief minimum the light of the system is only $7^M.59$, that is, more than two and a half times less than at the constant period. The two components that make up *RS Sagittarii*, are, consequently, of unequal brightness.

Calling the brighter or primary star, A, and the fainter, B, the question immediately meets us as to whether at chief minimum it is A that eclipses B, or B that eclipses A. Naturally we might expect that at chief minimum it would be the fainter star that eclipses the brighter, and at secondary minimum the fainter star that is occulted by the primary.

The question, however, admits of rigorous solution. Let

L_A = light of primary star (A).

L_B = light of secondary star (B).

mL_A = amount of light of star (A) not obscured when (B) eclipses it.

nL_B = amount of light of star (B) not obscured when (A) occults it.

Then transforming by means of the light-ratio already given, the magnitudes $6^M.60$, $6^M.89$, $7^M.59$, of the constant, secondary minimum, and chief minimum phases, into light-values, we obtain the three equations

$$L_A + L_B = 1.00 \qquad (1)$$

$$L_A + nL_B = .74 \qquad (2)$$

$$L_B + mL_A = .36 \qquad (3)$$

In these equations there is no distinction as to brightness, although in the explanation of nomenclature, A was called the primary star. This was done for future simplification; in the above equations no such assumption is made; A may be either of the two stars. Solving the equations, we obtain

$$m = \frac{36n - 10}{100n - 74} \qquad (4)$$

Now, n and m must be zero or positive proper fractions. To fulfil these conditions n must lie between $\frac{10}{36}$ and 0; that is the greatest possible value of B is 0.36, and the least possible value of A is 0.64. That is, A is at least nearly twice as bright as B, and chief minimum accordingly takes place when the faint companion eclipses the primary star.

The eccentricity of the orbit has already, in a general manner, been referred to. The fact, that secondary minimum happens almost midway between two chief minima, indicates that the line of apsides lies nearly in the line of sight. We next proceed to deal with the position of the orbit in space, at least as regards its periastron and apastron points. The most natural conclusion to come to would be that at chief minimum the star is passing through apastron; and at periastron, secondary minimum takes place. But with an inclination of about 4° or 5° and with a large eccentricity, it might be possible that the secondary and shorter minimum took place at apastron, the eclipse being at that point a very partial one.

It is easy to prove that such conditions of eclipse could not take place.

Referring to equation (4), we notice that n (that is the amount of the disc of B not obscured during its transit behind A) must, in the case where secondary minimum takes place at apastron passage, be greater than $\frac{1}{2}$, a limitation which makes m either negative or integral.

We have thus been able, rigorously, to determine the general facts concerning the orbital movement of *RS Sagittarii.*

RS Sagittarii is a close binary, one star being nearly twice as bright as the other. The orbit is eccentric, the line of apsides nearly coinciding with the line of sight. Apastron passage lies almost directly between the principal star and the earth, and chief minimum takes place when the faint companion eclipses the primary, that is when it is in apastron.

These are general statements; fortunately it is possible from the data at our disposal to make them more definite.

We once more make use of the important equation (4).

As the duration of chief eclipse is $12^h\ 50^m$, and of secondary eclipse 8^h, we can obtain by a graphical solution the eccentricity of the orbit that would yield these times of passing through apastron and periastron.

The eccentricity determined in this approximate way was $$e = 0.24$$

At apastron, accordingly, B will be nearly twice the distance from A that it is at periastron. Assuming the correctness of the light-ratio we have adopted, it is evident that the eclipse of A by B is not a total one, since the definite values of equations (2) and (3) do not equal that of (1). And, as the distance of the two stars at apastron is nearly twice the distance at periastron, whatever may be the inclination of the system,

$$m > \tfrac{3}{2}\, n \tag{5}$$

The highest value of n which satisfies this condition (equation 4) is $n = \frac{1}{14}$, in which case $m = \frac{1}{9}$, when $n = o$, $m = \frac{1}{7}$.

The "annular eclipse" of A by B, which would occur if the eclipse were a central one, would be evident as a period of constant magnitude, at chief minimum, of nearly one hour's duration, a phase which I am convinced does not occur. There may however be a short constant period of about ten or twenty minutes. As already stated, the principal object of my observations was to secure measures all along the light-curve. I considered this of more immediate importance than the more rigorous determination of the exact moment of minimum passage. When *RS Sagittarii* comes into view again at the beginning of the year, I intend directing my attention especially to the question of the existence of a constant period at chief minimum. Such a determination, when considered in relation to a well determined light-ratio, would yield a definite value of the inclination of the line joining the centers of the two stars to the line of sight.

We may, however, from the extreme values of m and n, given above, determine between what limits this inclination must be.

To do so, we first determine the values of

$$\tfrac{1}{2}\,(d_A + d_B)$$

d_A and d_B being the diameters of A and B respectively.

Considering the line of apsides to lie in the line of sight, we note that the two discs are apparently in contact; that is, secondary minimum begins 4 hours before periastron passage. The mean anomaly of this point is 24°.9. Adopting the approximate value, $e = 0.24$, the true anomaly and radius vector of the point become

$$v = 40°.5 \quad , \quad r = 0°.798$$

but $$\tfrac{1}{2}\,(d_A + d_B) = r \sin v = 0.518 \tag{6}$$

Again we note that the chief minimum commences $6^h\ 25^m$ before apastron passage. The mean anomaly of this point is 140°.2, wherefore

$$v = 154°.4 \quad , \quad r = 1°.202$$

and $$\tfrac{1}{2}\,(d_A + d_B) = 0.519 \tag{7}$$

The close agreement between the values (6) and (7) indicates that the value of the eccentricity obtained graphically is extremely correct.

We have now the following data for our determination of the extreme limits of the inclination,

$$\tfrac{1}{2}(d_A + d_B) = 0.52 \quad , \quad n = \tfrac{1}{14}$$
$$e = 0.24 \quad , \quad m = \tfrac{1}{9}$$

A simple geometrical solution yields the values

$$\tfrac{1}{2}\,d_A = \tfrac{1}{2}\,d_B = 0.26 \quad , \quad i = 1°.5$$

This is the greatest possible inclination. With central eclipse these values become

$$\tfrac{1}{2}\,d_A = 0.27 \quad , \quad \tfrac{1}{2}\,d_B = 0.25 \quad , \quad i = 0°.$$

Practically, therefore, the two stars that make up *RS Sagittarii* are equal in size.

Up to this point we have assumed that the apsidal line, and the central line, — using this term to designate the line joining the centers of the two stars when at central minimum phase, — coincide. This assumption will have no real influence on any of the results already deduced from the elements of variation, inasmuch as the two lines practically coincide. They would absolutely coincide if the secondary minimum took place exactly midway between two chief minima. The secondary minimum is, however, 30^m nearer the preceding than the following chief minimum.

This displacement indicates that the apsidal line is distant 1°.6 from the central line; and further that the fainter star *B*, passes through periastron a few minutes *before* reaching secondary minimum.

With this value of the angular distance between the apsidal line and the central line, a rigorous value of the eccentricity may be computed.

The final value of the eccentricity, taking into account this displacement, was

$$e = 0.245$$

a value so accordant with that adopted in the preceding part of this investigation, that it is unnecessary to repeat any of the computations.

Collecting all the results obtained: —

a) *RS Sagittarii* is composed of two stars almost exactly equal in size, but one of which is at least twice brighter than the other. If there be any difference in the size of the stars, then *A* is very slightly greater than *B*.

b) The orbit is eccentric, the amount of eccentricity being 0.245. The apsidal line is inclined 1°.6 to the central line. Periastron lies on the side remote from the earth, and the fainter star, *B*, passes through periastron 9^m before it reaches the middle of the secondary minimum.

c) The inclination of the central line to the line of sight may range from zero to 1°.5.

d) Taking the semi-axis major as equal to unity, the diameter of either *A* or *B* is equal to 0.52; accordingly, at periastron, the two stars come within 0.24 units of one another.

These results are based on well determined data, and will only, probably, be slightly modified by future observation and research. One is tempted to move beyond the limits of definite determination and speculate on the actual dimensions of this interesting system. It were better, however, to leave such speculation until the time when spectrosopic investigation will yield the necessary information for an absolute determination of the dimensions of the system. In expressing this hope, I am well aware of the difficulties in the way of estimating the velocity in the line of sight of stars fainter than 6^M. It may be, however, that the purer air of the Cape peninsula will render such a determination possible.

December 1895.

PHOTOGRAPHIC REFRACTIONS*. (REPLY TO PROF. JACOBY'S NOTE, *A.J.* 366.)

By F. W. DYSON.

In *A.J.* 350, Prof. Jacoby obtained expressions for the refraction on photographic plates which differed from those previously given by Prof. Turner in the *Monthly Notices* of the Royal Astronomical Society for 1893 November. These formulas Prof. Jacoby considered to be erroneous, but I pointed out in *A.J.* 354 that the difference arose from the fact that Prof. Jacoby's formulas were corrections to the *Right-Ascension and Declination*, and Prof. Turner's to the measured rectangular coordinates on the plate.

Replying to my note in *A.J.* 366, Prof. Jacoby considers a numerical example, and obtains correct results with his own expressions and wrong ones with Prof. Turner's. It seems to me that the first result is obtained by using the same symbols with different meanings in the course of the work. and the second through a misunderstanding and wrong application of Prof. Turner's formulas.

Taking Prof. Jacoby's example: if ξ, η are the coordinates of a star uncorrected for refraction on a plate whose center is at R.A. 0° 0′ 0″ and N.P.D. 30° 0′ 0″, then $\xi + \Delta\xi$, $\eta + \Delta\eta$ are the coordinates of the star corrected for refraction on a plate whose center is also at R.A. 0° 0′ 0″ and N.P.D. 30° 0′ 0″

$$\text{(I)} \quad \text{when} \quad \Delta\xi = -k'\{x-\xi(1+x^2)-\eta xy\}$$
$$\text{and} \quad \Delta\eta = -k_0'\{y-\xi xy-\eta(1+y^2)\}$$

These are the formulas quoted by me in *A.J.* 354 from *M.N.* 1893 November.

Taking $\xi = 60'.000$ $\eta = 60'.000$, we obtain from (I)

$$\xi + \Delta\xi = 59'.5980 \quad , \quad \eta + \Delta\eta = 59'.5962$$

From these we obtain for the apparent position of the star

$$p = 29°\ 0'\ 57''.00 \qquad \alpha = 2°\ 3'\ 41''.24$$

and for the corrected position

$$p = 29°\ 0'\ 58''.86 \qquad \alpha = 2°\ 2'\ 51''.39$$

These agree within 0″.03 of the values Prof. Jacoby finds for them directly from formulas quoted from Chauvenet's Astronomy, and verify the accuracy of the formulas.

Prof. Jacoby took Prof. Turner's formulas to mean that ξ, η, being the uncorrected coordinates on a plate whose center is at R.A. 0° 0′ 0″, N.P.D. 30° 0′ 0″, then

$$\xi + k'\{(1+x^2)\xi + xy\eta\}$$
$$\text{and} \qquad \eta + k'\{xy\xi + (1+y^2)\eta\}$$

are the corrected coordinates on a plate whose center is at R.A. 359° 59′ 9″.32, N.P.D. 30° 0′ 3″.65 (the true place corresponding to the apparent place R.A. 0° 0′ 0″, N.P.D. 30° 0′ 0″).

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*I am indebted to Prof. Turner for several suggestions in this note. He had written a reply to Prof. Jacoby's article in *A.J.* 366, but placed it at my disposal when he heard that I was writing one.

This is entirely different from what the formulas state. namely that

$$\xi - k'x + k'\{(1+x^2)\xi + xy\eta\}$$

and

$$\eta - k'y + k'\{xy\xi + (1+y^2)\eta\}$$

are the corrected coordinates on a plate whose center is at R.A. 0° 0′ 0″ , N.P.D. 30° 0′ 0″ and which has been verified above.

It may easily be shown that the corrected coordinates on a plate whose center is at R.A. 359° 59′ 9″.32 and N.P.D. 30° 0′ 3″.65 are given by the expressions

$$\text{(II)}\qquad \xi + k\{(1+x^2)\xi + (xy - x\cot P)\eta\}$$

and

$$\eta + k\{(xy + x\cot P)\xi + (1+y^2)\eta\}$$

which differ from those given both by Prof. TURNER and Prof. JACOBY.

The formulas used by Prof. JACOBY

$$\text{(III)}\qquad \xi + k'\{(1+x^2) - y\cot P\}\xi + k'\{xy - x\cot P\}\eta$$

and

$$\eta + k'\xi\{xy + x\cot P\} + k'(1+y^2)\eta$$

only give correct results by using P to mean two different quantities in the same piece of work. In deducing $\alpha - A$ and $p - P$ from the formulas of transformation $q = P - \tan^{-1}\eta$

$$\text{(IV)}\qquad \tan(\alpha - A) = \xi\cos(P-q)\,.\,\operatorname{cosec} q$$

$$\tan p = \tan q\,.\,\sec(\alpha - A)$$

it is assumed that $A = 0°\,0'\,0''$ and $P = 30°\,0'\,0''$ but when α and p are determined from the deduced values of $\alpha - A$ and $p - P$, it is assumed that $A = 359°\,59'\,9''.32$ and $P = 30°\,0'\,3''.65$.

The difference between the results obtained from the formulas (IV) according as P is taken to be 30° 0′ 0″ or 30° 0′ 3″.65 is not, as stated by Prof. JACOBY, negligible; in this example it is certainly small, but a difference of 0″.11 expressed in arc of a great circle is produced in the resulting right-ascensions, the equivalent of the term $ky\cot P\,.\,\xi$ in Prof. JACOBY's formulas (III) and is the difference between $d\{(\alpha - A)\,.\sin P\}$ given by Prof. JACOBY in *A.J.* 354 as equal to $d\xi$, and $\sin P\,.\,d(\alpha - A)$ which he previously gave as equal to $d\xi$ in *A.J.* 350.

The misunderstanding has in part arisen from the use of the ambiguous phrase *differential refraction*. Prof. TURNER uses the term to mean the difference between the correction to be applied to a star whose uncorrected coordinates are ξ, η and one at the center of the plate, to obtain its correct coordinates on a plate whose center is — in the above example — at R.A. 0° 0′ 0″ , N.P.D. 30° 0′ 0″. The term might be used to mean the correction to be applied to ξ, η to obtain the corrected coordinates on a plate whose center is at R.A. 359° 59′ 9″.34 and N.P.D. 30° 0′ 3″.65. It may further be used in the sense Prof. JACOBY uses it, of corrections to the right-ascension and declination.

There is one point with regard to the formulas given by Prof. TURNER which deserves notice. Right-ascensions and declinations are not involved explicitly. As refraction has nothing to do with the Earth's rotation but depends merely on the zenith-distance, it is clear, *a priori*, that the refractions in the two directions on a photographic plate depend only on the coordinates of the star and the coordinates of the zenith. The introduction of right-ascensions and declinations unnecessarily complicates the question. Further, it is a distinct advantage of Prof. TURNER's formulas that they give the corrected coordinates of the stars on plates whose centers are at the exact places required, *e.g.* in this instance at R.A. 0° 0′ 0″ , N.P.D. 30° 0′ 0″. As to the accuracy of the formulas, there was hardly need for numerical verification; the method by which they are obtained, given in *M.N.* 1893 Nov., is so simple and short, that there is little room for error, and the working may be readily verified.

OBSERVATIONS OF COMET *a* 1896,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 12-INCH EQUATORIAL.

BY PROFESSOR EDGAR FRISBY.

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

1896 Washington M.T.		*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Feb. 27	7 10 52.4	1	19 , 4	+0 20.50	+ 4 33.9	23 2 8.86	+46 26 16.8	9.818	0.666
Mar. 3	6 51 25.2	2	20 , 4	−0 39.38	− 5 6.9	1 8 18.70	+51 45 48.8	9.829	0.144
5	7 8 46.8	3	20 , 4	+0 50.59	+ 7 17.6	1 45 7.11	+51 32 48.8	9.827	0.067
7	7 57 41.3	4	18 , 4	−0 10.36	+ 0 50.5	2 14 21.49	+50 49 53.1	9.851	0.366
9	7 23 11.9	5	19 , 4	+0 6.32	+ 0 12.5	2 36 35.58	+49 57 1.0	9.791	9.956
12	7 14 5.5	6	20 , 4	−3 40.92	− 3 58.4	3 2 7.65	+48 33 23.5	9.750	9.798
14	7 28 52.0	7	20 , 4	+0 32.12	+ 6 18.9	3 15 19.38	+47 40 11.8	9.755	9.958
17	7 20 30.6	8	9 , 2	+2 13.00	+13 15.2	3 31 1.56	+46 27 43.7	9.729	9.923
20	8 2 18.5	9	17 , 4	−0 1.02	+ 6 45.9	3 43 27.49	+45 24 15.6	9.771	0.242
21	7 42 46.2	10	15 , 3	+2 37.51	− 3 17.4	3 46 58.45	+45 5 16.6	9.749	0.153

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	23 1 19.86	−1.50	+46 21 41.9	+ 1.0	Deichmüller, Bonn A.G. Catal. 17411
2	1 8 59.21	−1.13	+51 50 43.0	+12.7	Rogers, Cambridge A.G. Catal. 566
3	1 44 17.37	−0.85	+51 25 16.4	+14.8	" Cambridge " " 846
4	2 14 32.40	−0.55	+50 48 47.0	+15.6	" Cambridge " " 1096
5	2 36 29.58	−0.32	+49 56 31.6	+16.9	Deichmüller, Bonn A.G. Catal. 2312
6	3 5 48.61	−0.04	+48 37 4.4	+17.5	" Bonn " " 2683
7	3 14 47.24	+0.02	+47 33 35.7	+17.2	" Bonn " " 2799
8	3 28 48.45	+0.11	+46 14 11.7	+16.8	" Bonn " " 3025
9	3 43 28.27	+0.24	+45 17 13.5	+16.2	" Bonn " " 3203
10	3 44 20.72	+0.22	+45 8 17.6	+16.4	" Bonn " " 3213

NOTE. — All observations since 1893 have been made at the new Naval Observatory. Longitude 5h 8m 15s.71 and Latitude 38° 55′ 14″.7.

OBSERVATIONS OF COMET *b* 1896 (*SWIFT*),

MADE AT THE LICK OBSERVATORY, WITH THE 12-INCH EQUATORIAL,

BY WILLIAM J. HUSSEY.

1896 Mt. Hamilton M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
April 16 8 26 28	1	8 , 6	−1 43.13	+4 56.3	3 38 20.61	+18 19 32.1	9.688	0.728
17 7 59 41	2	8 , 6	+1 8.28	−1 13.5	3 37 46.09	+20 55 49.3	9.699	0.710
7 59 41	3	8 , 3	−1 42.10	+0 27.2	3 37 46.06	+20 55 52.1	9.699	0.710

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 40 3.59	+0.18	+18 14 28.3	+7.5	Weisse's Bessel 111, 849
2	3 36 37.65	+0.16	+20 56 54.9	+7.9	Becker, Berlin A.G. Catal. 1103
3	3 39 27.99	+0.17	+20 55 17.0	+7.9	Becker, Berlin A.G. Catal. 1139

Mt. Hamilton, Cal., 1896 *April* 18.

OBSERVATIONS OF COMETS *a* AND *b* 1896,

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY PROF. MARY W. WHITNEY AND CAROLINE E. FURNESS.

1896 Greenwich M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ	Obs.
			COMET *a* 1896.						
h m s			m s	′ ″	h m s	° ′ ″			
Mar. 14 13 59 58	1	9	+0 52.56	+ 4 40.6	3 15 39.81	+47 38 33.5	9.810	0.475	F
17 15 57 7	2	7	+2 51.93	+10 12.5	3 31 40.49	+46 24 38.9	9.783	0.746	W
20 15 52 7	3	12	+0 24.00	+ 4 36.3	3 43 52.49	+45 22 9.3	9.778	0.742	F
31 14 11 33	4	10	+0 3.61	− 9 2.1	4 13 34.67	+42 36 34.4	9.776	0.598	W
Apr. 2 13 10 56	5	12	−0 6.65	+ 5 57.5	4 17 31.51	+42 14 5.7	9.752	0.464	W
			COMET *b* 1896.						
Apr. 22 13 16 39	6	10	+0 11.56	+ 3 21.6	3 30 22.93	+34 3 47.7	9.713	0.761	F

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 14 47.24	+0.01	+47 33 35.7	+17.2	Deichmüller, Bonn A.G. Catal. 2799
2	3 28 48.45	+0.11	+46 14 9.7	+16.7	" " " " 3025
3	3 43 28.27	+0.22	+45 17 16.5	+16.5	" " " " 3203
4	4 13 30.72	+0.34	+42 45 21.2	+15.3	" " " " 3554
5	4 17 37.80	+0.36	+42 7 53.3	+14.9	" " " " 3592
6	3 30 11.35	+0.02	+34 0 13.5	+ 9.6	Bonn VI. +33°682

ELEMENTS AND EPHEMERIS OF COMET *b* 1896 (*SWIFT*),

By A. O. LEUSCHNER and F. H. SEARES.

The following elements of Comet *b* 1896 (Swift) were deduced with the assistance of Mr. F. H. Seares, from observations secured at Mount Hamilton by Professor W. J. Hussey on April 16 and 17, and by Mr. R. G. Aitken on April 19. The observations were kindly telegraphed to the Students' Observatory by Prof. E. S. Holden.

$$T = \text{April } 17.6516 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \Omega &= 178^\circ\ 15'\ 31'' \\ \omega &= 1\ \ 45\ \ \ 5 \\ i &= 55\ \ 35\ \ 26 \end{aligned}\right\} \text{Mean Equinox } 1896.0$$

$$q = 0.56633$$

For the middle place (O−C):

$$\Delta\lambda \cos\beta = -1''.2 \quad , \quad \Delta\beta = +4''.4$$

Constants for the Equator.

$$x = [9.75293]\, r \sin(v + 270^\circ\ 46'\ \ 2'')\ \sec^2 \tfrac{1}{2} v$$
$$y = [9.68095]\, r \sin(v + 179\ \ 51\ \ 55)\ \sec^2 \tfrac{1}{2} v$$
$$z = [9.47915]\, r \sin(v + \ \ 3\ \ \ 3\ \ 13)\ \sec^2 \tfrac{1}{2} v$$

Ephemeris for Greenwich Midnight.

1896	App. α	App. δ	log Δ	Br.
	h m s	° ′		
April 23	3 28 1	+36 32.0	9.7576	1.00
27	3 14 29	+46 3.9	9.7738	
May 1	2 55 35	+53 48.0	9.8005	
5	2 32 14	+59 39.7	9.8321	0.50

University of California, Students' Observatory, 1896 *April* 21.

ELEMENTS AND EPHEMERIS OF COMET *b* 1896,

By Rev. GEO. M. SEARLE.

I have computed the following elements and ephemeris of Comet *b* 1896 from the Lick observations of April 16 and 19, with one made by myself on the 22d.

$$T = \text{April } 17.6338 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \omega &= 1^\circ\ 40'\ 47'' \\ \Omega &= 178\ \ 46\ \ 53 \\ i &= 55\ \ 33\ \ 30 \end{aligned}\right\} \text{Mean Equin. } 1896.0$$

$$\log q = 9.753120$$

Discordance for middle place (O−C). $\Delta\lambda = -11''$. $\Delta\beta = +3''$

These elements give the following coordinate equations:

$$x = [9.999867]\, r \sin(v + 270^\circ\ 42'\ 19'')$$
$$y = [9.928031]\, r \sin(v + 179\ \ 48\ \ 56)$$
$$z = [9.725675]\, r \sin(v + \ \ 2\ \ 57\ \ 58)$$

and the following ephemeris for Greenwich midnight:

1896	α	δ	log Δ	Br.
	h m	° ′		
April 30.5	3 0.8	+52 3	9.7928	0.71
May 1.5	2 55.6	53 50		
2.5	2 50.2	+55 27	9.8078	
May 3.5	2 44.5	+56 57		
4.5	38.5	58 22	9.8237	0.54
5.5	32.3	59 40		
6.5	25.9	60 53	9.8400	
7.5	19.3	62 0		
8.5	12.6	63 1	9.8561	0.40
9.5	2 5.8	63 57		
10.5	1 58.8	64 49	9.8720	
11.5	51.7	65 37		
12.5	44.6	66 20	9.8875	0.30
13.5	37.4	66 59		
14.5	30.2	67 36	9.9023	
15.5	23.0	68 10		
16.5	15.7	68 40	9.9165	0.23
17.5	8.5	69 8		
18.5	1 1.2	69 31	9.9300	
19.5	0 53.9	69 58		
20.5	0 46.7	+70 20	9.9427	0.19

The unit of brightness is that of the observation of Apr. 16.

COMET *b* 1896.

A comet was found by Prof. Lewis Swift, on April 13, in right-ascension $3^h\,39^m$, and declination +15° 40′, as read from the circles. Bright, short tail, motion slow, westerly.

NEW ASTEROID.

Prof. Lamp of the Kiel Observatory announces the detection by Prof. Wolf of a small planet upon a photographic plate of April 2.

CP 1896 April 2 $11^h\,0^m.6$ Heidelberg M.T. $\alpha = 12^h\,47^m.6$, $\delta = +2^\circ\,49'$. Daily motion, -60^s in α, and 9′ northward.

CORRIGENDA.

No. 368, p. 63, col. 1, line 20. *for* Jan. 23 *put* Jan. 3; col. 2, line 6, *for* $7^M.2$ *put* $9^M.2$.

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Comet *b* 1896.
New Asteroid.
Corrigenda.

Published in Boston, tri-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed April* 28.

THE

ASTRONOMICAL JOURNAL.

No. 374.

VOL. XVI. BOSTON, 1896 MAY 11. NO. 14

ON THE VARIABLE STAR *Z HERCULIS*,

BY N. C. DUNÉR.

In Vol. XVI, no. 6 (366) of the *Astronomical Journal*, Mr. YENDELL has published a very important series of observations of the star *Z Herculis* of the *Algol*-type. Mr. YENDELL has also made some observations on the length of the period; but as he has, in these, paid no regard to the article which I published April 1895 in the *Astrophysical Journal*, "On the Periodic Changes of the Variable Star *Z Herculis*," I have deemed it desirable to make a comparison of Mr. YENDELL's observations with the ephemeris published there by me, p. 289. The results are the following:

I EVEN MINIMA

Greenwich M.T.		Obs.-Comp.
	h m	m
1895 July 30	17 52	+22
Sept. 4	16 15	+28
8	15 31	− 4
20	14 53	− 8
24	14 30	−20

II UNEVEN MINIMA

Greenwich M.T.		Obs.-Comp.
	h m	m
1895 Apr. 23	19 36	[−85]
June 14	18 45	+15
July 28	15 51	−34
Aug. 5	16 18	+17
25	14 56	− 7
Sept. 2	14 10	−22
10	13 52	−25
22	13 47	+ 5

Consequently, in the mean of these, the total of the observations will be represented as follows by the elements computed by me, if we exclude the evidently erroneous one of April 23.

$$\text{Even minima} \quad (O-C) = +2^{m}$$
$$\text{Uneven minima} \quad = -7$$

The accordance is therefore yet to be regarded as a complete one, and it would be needless to make a new computation until new observations are at hand. In the above comparison, as well as in the original computation, I have disregarded the reduction to the sun.

The observations of Mr. YENDELL afford an admirable confirmation of the general accuracy of the theory given by me, and this is so much the more valuable since the very circumstance, that Mr. YENDELL evidently used in his observations not my ephemeris but Prof. HARTWIG's, proves that his observations were in no wise influenced by my computations.

In one respect only do the observations of Mr. YENDELL appear to be in conflict with my theory. According to Mr. YENDELL the magnitudes of the star were,

At the principal minimum	$7^{M}.94$
" " secondary minimum	$7^{M}.75$

But these values are contradicted:—

1. By the observations based upon the determinations of magnitude by Mr. LINDEMANN at Pulkowa, made by me and my assistant at this observatory, Mr. ÖSTEN BERGSTRAND, which have given

	M	
Magnitude at maximum	6.89	Lindemann
" " principal minim.	8.05	"
" " secondary "	7.35	Dunér and Bergstr.

II. By the observations of HARTWIG in 1894. For if at the beginning of HARTWIG's observations of the secondary minima the star had not been brighter than $7^{M}.75$, it would have been impossible for him to assume the uneven minima at a time of day so much earlier than that of the even minima as he made this actually to be. But if, on the other hand, we assume that my value for the brightness of the star at the secondary minimum is the correct one, then HARTWIG, who did not know that the minima are of different brightness, must have unquestionably assumed that the uneven minima occurred at a time of day about four hours earlier than the even ones.

III. By the statements of Mr. YENDELL himself. For he says "The odd or secondary minima were found difficult of observation from the small range of the variation and the indefiniteness." This must be a perfectly accurate description of the phenomenon, provided the whole amplitude amounted only to from $6^{M}.89$ to $7^{M}.35$. But if this were from $6^{M}.89$ to $7^{M}.75$, the minima must on the other hand have been sharp and easy of observation; in fact, easier than those of *Y Cygni*, *U Ophiuchi*, etc. I must, therefore, maintain the correctness of my theory in this regard also.

Finally, in order to see when and where the star may be observed with advantage, I have computed the following ephemeris.

EVEN MINIMA Epoch		h	m	UNEVEN MINIMA Epoch		h	m
300	1896 May 9	3	52	301	1896 May 11	2	33
350	Aug. 16	23	4	351	Aug. 18	21	45
400	Nov. 24	18	16	401	Nov 26	16	57
450	1897 Mar. 20	13	28	451	1897 Mar. 22	12	9
500	June 6	8	40	501	June 8	7	21
550	Sept. 14	3	52	551	Sept. 16	2	33
600	Dec. 22	23	4	601	Dec. 21	21	45
650	1898 April 1	18	16	651	1898 April 3	16	57
700	July 10	13	28	701	July 12	12	9
750	Oct. 18	8	40	751	Oct. 20	7	21
800	1899 Jan. 26	3	59	801	1899 Jan. 28	2	33

The conditions are not favorable. In 1896 the star can only be observed in Australia and Asia, in 1897 only in the most eastern part of Europe and in west Asia, in 1898 in eastern America, and the uneven minima in part also in western Europe. Not until 1902 will this star probably be observable under favorable conditions in middle Europe. It is therefore to be feared that this highly interesting star may be sadly neglected.

Upsala, 1896 *March* 4.

NOTES ON VARIABLE STARS,

BY JOHN M. THOME.

I have been interested by the statements in Nos. 362 and 363 of this Journal concerning the new variable stars, and offer the following additional testimony.

4885. *Z Centauri.*

With regard to the object found on the Arequipa photographs (*A.J.* 362) which Prof. PICKERING announced as a new star, our record shows that I saw both the nebula and the star, 1887 April 12, but the nebula was not noted on two other dates. Our estimates were: 1885 May 4, 9^{M}; 1887 March 26, $9\frac{3}{4}^{M}$; April 12, $9\frac{1}{2}^{M}$. That our observations were of the star, is proved by the revision 1892 July 19, when the star was $9\frac{1}{2}^{M}$, but the nebula could not be seen, although specially looked for. This is not strange, for our low power, 15, and the small effective aperture of the objective, three inches, will not permit two such faint and closely-lying objects to be seen separately, except under the most favorable circumstances.

7151. *RU Sagittarii.*

Besides the two General Catalogue stars cited by Prof. CAMPBELL (*A.J.* 363), there is another which entered into the problem as we struggled with it upon the meridian circle. The three stars, as given in our Catalogue for 1875.0, are

	M	h m s	° ′ ″		
27305	8	19 50 6.71	−42 10 48.6	Lac. 8276	Observed once in 1875
27306	$9\frac{1}{4}$	50 12.21	9 59.0		One obs. in 1876 and 4 in 1877
27312	$7\frac{3}{4}$	19 50 33.67	−42 9 51.9		Two obs. in 1875, 6 in 1876, and 4 in 1877

Now, the very fact that a Lacaille star appears with only one observation in the General Catalogue, while two others, in close proximity, are repeatedly observed, in different years, shows that the object is suspicious; and the evolution of 27306, with the large number of observations of 27312, is sufficient indication of what the state of the Director's mind was, and how nearly he came to discovering its variability. Referring to our record-books, I find the following notes:

1875 Sept. 9	G.C. 27312	observed ;		"a fainter star precedes by 28ˢ, 1′ S."
10	" 27305	"	8^{M}	
10	" 27312	"	$7\frac{1}{2}^{M}$	
1876 Aug. 12	" 27306	"	$9\frac{1}{2}^{M}$;	"a $7\frac{3}{4}$ follows 20ˢ same decl." (27305 probably invis.)
2	" 27312	"	no mag. ;	"a fainter star precedes" (27305 probably invis.)
11	" 27312	"	—	"only bright star"
23	" 27312	"	—	"only a faint star precedes" (27306)
1877 Aug. 28	" 27312	"	$7\frac{3}{4}^{M}$;	"a faint star (27306) precedes"
Sept. 9	" 27306	"	9^{M} :	"no other"
19	" 27306	"	$9\frac{3}{4}^{M}$:	"a star precedes by 5ˢ, 1′ S., but too faint to observe"
30	" 27306	"	9^{M} ;	no note of another

From this it would seem that 27305, the variable, was always fainter than $9\frac{1}{2}$, probably than $9\frac{1}{4}$, during the period of the 1876 and 1877 observations.

7266. *RT Sagittarii.*

I have already stated, in No. 360, that we saw only one star here, and I suppose both estimates are of the variable star: unless, indeed, this was invisible at that time. The companion-star seems, however, to be hardly as bright as 10^{M}, and I adhere to my former assumption. The nearest estimate in declination, that we can make, is to tenths of the scale, or 1′, and faint objects lying closer than 2ˢ would be seen as one.

In the same number of the Journal, our observed place for 5511 *RS Librae* is erroneously given as 20ˢ. It should be 2ˢ.0, as its current number, 10973½, indicates.

Cordoba, 1896 *Feb.* 22.

ELEMENTS OF VARIATION OF 8598 *U PEGASI*,

By S. C. CHANDLER.

It has been my intention not to publish detailed results for the above star until more observations could be incorporated. But, from a preliminary discussion, so marked an effect of a well known form of subjective error has become palpable, that it seems desirable to warn observers in order that they may arrange their scheme of observation for the coming season so that it may be investigated and eliminated. I allude to the systematic effect, arising from unequal sensitiveness of different portions of the retina, dependent on varying position of the variable relative to its comparison-stars, in different hour-angles. It has been my practice in the case of this star to begin as early in the evening as possible and measure its brightness, at quarter or half-hour intervals, continuously for seven or eight hours in some instances, until daylight or the setting of the star. During these long intervals the parallactic angle changed nearly 100°. As a consequence, a comparison-star which was in a vertical line with the variable in the beginning, was horizontal with it at the end, or *vice versa*. The result is that the light-curve is apparently distorted, and the times of the phases accelerated or retarded. This troublesome phenomenon has been known to all careful observers for more than half a century, and requires especial precautions for the avoidance of its influence. In order to analyze its operation in the present case, the following times of minima have been deduced solely from the comparisons with the stars *c* and *d* (see *A.J.* XV, 181), and those of maxima solely from the stars *a* and *b*; and for greater certainty, only those phases have been used for which a part of both increase and decrease were observed. The last column *q*, gives the mean parallactic angle for the observations used.

MINIMA.

E	Observed Camb. M.T.	d	h	m	p	Mag.	Red. to ⊙	q
		d	h	m			m	°
0	1894 Sept.	22	11	30	$\frac{1}{4}$	. .	+7.9	− 7
14		25	16	30	$\frac{1}{4}$	. .	8.0	+50
1694	1895 Oct.	18	8	50	2	9.65	7.4	−25
1695		18	13	38	1	9.60	7.4	+47
1698		19	7	12	3	9.72	7.3	−42
1707		21	8	44	4	9.63	7.2	−30
1716		23	9	55	5	9.70	7.1	+ 4
1720		24	8	52	1	9.55	7.1	−27
1721		24	13	14	2	9.63	7.1	+48
1725		25	11	44	3	9.62	7.0	+38
1733		27	8	18	4	9.63	6.8	−23
1737		28	6	44	3	9.62	6.8	−42
1763	Nov.	3	6	55	2	9.68	6.3	−35
1768		4	10	0	2	9.62	6.2	+25
1772		5	8	15	1	9.72	+6.1	−20

MAXIMA.

E.	Observed Camb. M.T.	d	h	m	p	Mag.	Red. to ⊙	q
		d	h	m			m	°
1720	1895 Oct.	24	11	29	5	8.90	+7.1	+36
1724		25	10	0	3	8.98	7.0	+ 9
1732		27	5	50	2	9.02	+6.8	−47
1733	1895 Oct.	27	10	30 ::	0	8.97	. .	+20
1737		28	9	0	1	9.00	+6.8	−13
1745		30	6	— ::	0	9.03	. .	−47
1754	Nov.	1	7	38	2	9.03	6.5	−30
1763		3	9	14	5	8.85	6.3	+ 1
1767		4	7	50	3	9.00	+6.2	−22

Comparing the heliocentric times with my newest elements,

$$\left.\begin{array}{lll}\text{Min. 1891 Sept. } 22^{d}\ 16^{h}\ 41^{m}.3 & \text{Greenw. M.T.} \\ \text{Max.} \qquad\qquad 22\ \ 19\ \ 45.3 & \text{“} \quad \text{“}\end{array}\right\} +5^{h}\ 32^{m}.25\ E$$

and arranging in order of the angle *q*, we have the following table:

MINIMA.

E	q	O—C	r	p
	°	m	m	
1698	−42	+42.0	+16.8	3
1737	−42	+15.8	− 9.4	3
1763	−35	+27.8	+ 6.8	2
1707	−30	+23.7	+ 5.7	4
1720	−27	+32.3	+16.1	1
1694	−25	+29.1	+14.1	2
1733	−23	− 1.2	−15.0	4
1772	−20	− 2.6	−14.6	1
0	− 7	−18.8	−23.0	$\frac{1}{4}$
1716	+ 4	−15.6	−13.2	5
1768	+25	− 8.5	+ 6.5	2
1725	+38	−17.0	+ 5.8	3
1695	+47	−15.1	+13.1	1
1721	+48	−37.9	− 9.1	2
14	+50	−50.2	−20.2	$\frac{1}{4}$

MAXIMA.

E	q	O—C	r	p
1732	−47	− 0.9	. .	2
1754	−30	− 2.7	. .	2
1767	−22	+ 9.7	. .	3
1737	−13	−32.2	. .	1
1763	+ 1	−17.2	. .	5
1724	+ 9	+27.2	. .	3
1720	+36	+ 5.3	. .	5

The effect of the subjective error mentioned is unmistakably manifest in the column O−C for the minima. Its correction, $+0^{m}.6\,q$, when applied, gives the values in column *r*, which may be regarded as the true accidental deviations.

In the maxima no such effect appears. There is a reasonable and satisfactory explanation why the phenomenon appears in the minima and not in the maxima. The stars *c* and *d*, used for the former, are in the same line with the variable, and this line is horizontal near the eastern prime vertical, but vertical near the western. On the contrary, one of the stars, *a* or *b*, used for the latter, is in a horizontal, the other in a vertical line with the variable, whether the observation is made east or west.

The probable error in the time of a well observed minimum (wt. 4), is $\pm 6^{m}$, and of maximum, $\pm 10^{m}$. This illustrates the accuracy with which the phases can be determined, the precision being entirely comparable with that of minima of stars of the *Algol*-type.

From the column of observed magnitudes the mean brightness at minimum is $9^M.64$, and that at maximum is $8^M.99$. The average discordance from the mean is only $\pm 0^M.04$, in both cases.

It therefore appears, from the above discussion, that the light-curve is perfectly regular, so far as observation can distinguish. The same is true of the period, at least within the interval embraced by this series.

By a corresponding treatment of YENDELL's observations, as published, we find a similar correction for parallactic angle in his case, with possibly a slightly larger coefficient: and that it will satisfactorily dispose of the anomalies of which he has spoken.

One important point in conclusion. The duration of increase in this star is $3^h\ 4^m$, and its ratio to the whole period is 0.554. A comparison with all the other known variables of the ordinary type, of a period under 6 days, shows

	Period d	*R*
U Pegasi	0.23	0.554
R Muscae	0.88	0.334
T Trianguli australis	0.98	. .
U Trianguli australis	2.55	0.298
R Trianguli australis	3.39	0.245
Y Carinae	3.64	0.253
W Carinae	4.38	0.205
T Vulpeculae	4.44	0.293
T Velorum	4.60	0.391
S Crucis	4.69	0.320
δ Cephei	5.37	0.300
Y Sagittarii	5.77	0.312
R Crucis	5.83	0.240

The average ratio, *R*, of increase to period, for the other stars, is 0.290. We may therefore regard *U Pegasi*, provisionally, as a type of variability distinct from this class of stars, as it evidently is from those of the *Algol*-type.

It is manifest that future observations should be planned so that the error here treated of may be determined and eliminated, with the head placed in different and determinate positions with reference to the separate comparison-stars. Further, since the same phases may be observed in Europe and America under different hour-angles — which will permit the elimination in a still more satisfactory way — it is earnestly hoped that the star may be quite generally followed during the coming season.

OBSERVATIONS OF *VESTA*,

MADE AT THE STUDENTS' OBSERVATORY, UNIVERSITY OF DENVER, COLORADO,

BY JOHN DICKERMAN.

1895 University Park M.T.		⁎	No. Comp.	Planet — ⁎		Planet's apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Sept. 4	10 9 47	1	21 , 10	+2 12.02	+3 44.0	22 22 19.94	−20 42 10.2	*n*8.535	0.882
5	9 23 9	2	21 , 10	+1 12.25	−1 34.9	22 21 29.19	−20 47 28.7	*n*9.378	0.864
6	8 42 10	3	24 , 10	+2 49.51	−2 24.0	22 20 39.10	−20 51 38.9	*n*9.480	0.852
9	8 49 46	4	24 , 10	+0 5.13	+0 50.7	22 18 9.34	−21 7 40.9	*n*9.424	0.861
Nov. 15	7 40 7	5	15 , 5	+1 18.15	−6 7.5	22 21 57.14	−18 38 20.7	8.940	0.871
16	7 20 33	6	20 , 10	+0 23.06	+8 41.4	22 22 48.76	−18 31 12.8	9.070	0.868
19	6 12 35	7	20 , 10	−1 54.90	−7 10.0	22 26 59.07	−18 9 50.1	*n*8.580	0.870
Dec. 3	7 11 31	8	20 , 5	+0 23.75	+1 50.6	22 40 9.90	−16 11 15.3	9.218	0.855
4	6 35 35	9	17 , 5	+0 50.27	+2 31.4	22 41 16.68	−16 5 43.3	8.998	0.860

Mean Places for 1895.0 of Comparison-Stars.

⁎	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 20 3.77	+4.15	−20 46 11.2	+17.0	Argent. Gen. Catal. 30602
2	22 20 12.79	+4.15	−20 46 10.7	+16.9	Anon. fol. Munich I, 30893, by 36^s.12, S. 12′ 24″.2
3	22 17 45.44	+4.15	−20 49 31.5	+16.6	Munich I, 30824
4	22 18 0.05	+4.16	−21 8 46.7	+15.1	Yarnall 10091
5	22 20 35.41	+3.55	−18 32 25.6	+12.4	Munich I, 30923
6	22 22 22.16	+3.54	−18 40 6.4	+12.2	Anon. fol. Yarnall 10125, 1^m 59^s.35, N. 13′ 9″.9
7	22 28 50.43	+3.54	−18 2 53.1	+13.0	Munich I, 31192
8	22 39 42.72	+3.43	−16 16 19.9	+14.0	Anon. prec. Yarn. 10348, 9^m 22^s.07, N. 6′ 24″.1
9	22 40 22.99	+3.42	−16 8 28.7	+14.0	" " " " 8^m 41^s.80, N. 11′ 15″.3

The above observations were made with a six-inch Grubb equatorial and filar micrometer. The magnifying power was 76 diameters. The latitude of the observatory is 39° 40′ 35″.1. The longitude is $6^h\ 59^m\ 47^s.81$ west of Greenwich.

OBSERVATIONS OF *MIMAS*,

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY ORMOND STONE.

The angles here given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction.

Mimas–Enceladus.

1894	Eastern St. Time	p	Eastern St. Time	s
	h m s	°	h m s	″
Apr. 27	13 47 10	9.45	13 51 38	5.71
	14 0 37	21.17	13 55 4	5.79
May 1	9 2 42	189.92	9 5 43	4.62
	9 12 58	195.18	9 8 12	4.66
	9 48 1	222.61	9 50 59	7.24
	9 56 29	223.81	9 52 49	7.11
2	9 54 15	99.83	9 58 54	43.23
	10 6 50	100.63	10 3 21	43.51
26	9 42 4	278.55	9 44 58	44.64
	9 49 51	278.57	9 47 9	44.56
June 2	11 6 57	82.84	11 10 1	43.15
	11 14 2	82.87	11 12 9	43.27
11	9 37 40	262.45	9 40 30	42.65
	9 45 40	262.24	9 42 40	43.03

Mimas–Tethys.

1894	Eastern St. Time	p	Eastern St. Time	s
	h m s	°	h m s	″
Mar. 27	14 21 29	263.90	14 27 56	21.51
	14 36 47	264.32	14 31 35	21.36
Apr. 15	8 57 13	259.38	9 1 22	17.66
	9 7 31	260.10	9 3 47	17.85
	10 40 24	263.10	. .	. .
May 1	9 35 57	88.24	9 39 58	74.44
	9 44 42	88.41	9 42 11	74.50
2	9 7 2	261.76	9 13 59	20.01
	9 34 2	263.57	9 17 39	20.26
26	9 57 43	248.31	10 0 15	20.59
	10 6 33	247.44	10 3 9	20.53
June 2	10 6 16	86.27	10 9 8	70.69
	10 14 39	86.15	10 11 27	70.53
June 11	9 47 53	282.73	9 50 45	42.43
	9 56 13	283.29	9 52 43	42.38

Mimas–Dione.

1894	Eastern St. Time	p	Eastern St. Time	s
	h m s	°	h m s	″
Apr. 15	9 11 9	67.75	9 15 33	32.76
	9 22 20	67.71	9 17 53	32.53
May 1	9 16 19	286.97	9 19 31	19.70
	9 23 52	286.03	9 21 5	19.80
	10 1 23	287.52	9 6 46	17.48
	10 17 1	287.44	9 11 27	17.34
26	9 31 23	293.03	9 34 18	31.96
	9 38 59	292.33	9 36 30	31.84
June 2	8 28 49	138.57	8 31 16	13.11
	8 35 29	138.83	8 32 48	13.15

Mimas–Rhea.

1894	Eastern St. Time	p	Eastern St. Time	s
	h m s	°	h m s	″
Mar. 27	14 42 53	308.96	14 48 52	18.22
	15 0 24	308.72	14 52 7	18.42
Apr. 15	9 25 51	77.43	9 30 3	74.94
	9 38 13	77.60	9 34 57	75.01
May 1	9 25 37	247.14	9 28 34	36.77
	9 34 23	247.25	9 31 31	36.78
	10 20 40	248.13	10 25 36	41.68
	10 32 11	248.58	10 28 2	41.68
26	9 20 46	75.53	9 23 36	44.96
	9 29 7	74.52	9 26 3	45.22
June 2	10 16 41	265.55	10 20 32	51.80
	10 25 12	264.92	10 22 52	51.75

Mimas–Titan.

1894	Eastern St. Time	p	Eastern St. Time	s
	h m s	°	h m s	″
Apr. 15	10 13 29	106.96	10 17 57	121.31
	10 27 45	107.40	10 21 46	121.03

Mimas–Iapetus.

1894	Eastern St. Time	p	Eastern St. Time	s
	h m s	°	h m s	″
June 2	11 17 27	324.62	11 20 37	179.18
	11 24 11	324.57	11 21 22	179.18

NOTE ON THE DIAMETERS AND ELLIPTICITY OF THE PLANET *URANUS*.

BY E. E. BARNARD.

In reference to my paper on the planet *Uranus* and his satellites in *Astr. Jour.*, no. 370, Professor YOUNG has kindly sent me a copy of his paper on "The Ellipticity and Surface-Markings of *Uranus*," which was printed in the *Astronomische Nachrichten*, volume 107, no. 2545, October 1883.

When I sent my paper to *A.J.*, I did not know of Prof. YOUNG's paper.

During the opposition of 1883, Professor YOUNG secured a set of measures of the polar and equatorial diameters of *Uranus* from which he deduced an ellipticity of about $\frac{1}{14}$.

These diameter-measures, which were made with the 23-inch, are in very close agreement with my measures as printed in *A.J.* 370, as will be seen by the following comparison:

DIAMETERS OF *Uranus*.

(Reduced to the mean distance of *Uranus* from the Sun.)

Polar	Equatorial	
3″.946	4″.273	Young, 1883 (8 nights)
3 .930	4 .150	Barnard, 1894 (9 nights)

During his measures Professor YOUNG occasionally saw very faint belts on the planet similar to those of *Jupiter* and *Saturn*. From micrometer-settings on these belts at different times he deduced a position-angle of about 37°. Since 1883 this angle would have decreased about 10° or 12°, so that the resulting position-angle of the equator of *Uranus* is in good agreement with the value given by me (28°) from my measures of the apparent ellipticity of the disc of the planet.

Kenwood Observatory, Chicago, Ill., 1896 *April* 4.

OBSERVATIONS OF LONG-PERIOD VARIABLES,

By PAUL S. YENDELL.

845. *R Ceti.*

Twelve observations of this star, from 1895 Dec. 6 to 1896 Feb. 1, show a maximum of about $8^{M}.8$ on 1895 Dec. 21. The magnitude at the first observation was $9^{M}.3$, and at the last, $9^{M}.2$.

980. *V Persei.*

Since the observations of this star were published in Vol. XV of this Journal, p. 35, it has been kept under observation; and a minimum, estimated to be of $10^{M}.6$ was passed 1895 Dec. 12. On 1896 Feb. 1 the star had increased to $9^{M}.8$.

1717. *V Tauri.*

From eleven observations of this star, extending from 1895 Dec. 6 to 1896 Feb. 1, a faint and rather uncertain maximum of this star seems to have taken place 1896 Jan. 12, at a magnitude of $9^{M}.4$.

Dorchester, Mass., 1896 *Feb.* 9.

2625. *V Geminorum.*

I have six observations of this star, as follows: It was first seen 1895 Dec. 16, and its light estimated at $9^{M}.3$; the next two observations show a sharp and distinct rise to $9^{M}.0$, which it reached Dec. 21, falling away rapidly from this date, until Feb. 1, when it was below all the comparison-stars, and estimated to be about 11^{M}.

7085. *RT Cygni.*

I have twenty observations of this star, from 1895 Nov. 27 to 1896 Feb. 8.

At the first date its light was about $9^{M}.7$, from which it steadily increased to a maximum of $6^{M}.8$, which it reached 1896 Jan. 10, declining at about the same rate until the last observation, when it had decreased to $7^{M}.9$.

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

By J. A. PARKHURST.

294. *W Cassiopeae.*

Since its maximum in 1895 July, this star declined slowly, with some apparent fluctuations, to a minimum, $11^{M}.4$, 1896 Jan. 19. It then rose slowly, till at the last observation, April 3, it was $10^{M}.0$. I have 52 observations since 1894 Dec. 8, covering somewhat more than one period. Taken in connection with ESPIN's estimates in the fall of 1887, a period of about 11 months is indicated.

678. *U Persei.*

I have 21 observations from 1895 Sept. 9 to 1896 April 3, giving a maximum, $7^{M}.2$, 1896 Jan. 22. The interval from the last maximum is 310 days; from the last minimum, 181 days.

1623. *T Camelopardalis.*

The position of this star as measured with the filar micrometer is

R.A.	Decl.	
$4^{h}\ 25^{m}\ 59^{s}.51$	$+65^{\circ}\ 50'\ 52''.7$	1855
4 30 21 .60	65 56 45 .1	1900

A maximum, $7^{M}.4$, is indicated by 21 observations from 1895 Sept. 30 and 1896 April 3, for 1896 Jan. 10.

5601. *S Ursae minoris.*

I have measured the place of this star with the following results:

R.A.	Decl.	
$15^{h}\ 35^{m}\ 18^{s}.58$	$+79^{\circ}\ 7'\ 13''.4$	1855
15 33 26 .73	78 58 17 .7	1900

The reference-points were DM. 78°518 and 519, and 79°467. The places of the first two for 1875 were kindly furnished by Prof. DUBIAGO from his unpublished Kasan *Astr. Gesells. Catalogue*. The last is in Bonn VI.

Magnitude-comparisons on 21 evenings from 1895 Oct. 2 to 1896 April 3 yield a maximum, $7^{M}.4$, 1896 Jan. 24. The star was $10^{M}.1$ at the first observation, and $9^{M}.2$ at the last.

6207. *Z Ophiuchi.*

I have 21 observations from 1895 May 19 to Nov. 26, showing a minimum, $11^{M}.8$, 1895 Oct. 3. The minimum, being more sharply defined than the maximum, is better adapted to determination of the star's period. The rates of decrease and increase were about equal. At the last observation the magnitude was $10^{M}.2$.

7085. *RT Cygni.*

I have 36 observations between 1895 Aug. 5 and 1896 Feb. 5, yielding a minimum, $11^{M}.9$, 1895 Oct. 12, and a maximum, $6^{M}.8$, 1896 Jan. 17. The minimum is especially well established.

8324. *V Cassiopeae.*

I have 37 observations from 1895 Aug. 8 to 1896 April 3. They yield a maximum, $7^{M}.5$, 1895 Oct. 21, and a minimum, $12^{M}.4$, 1896 Feb. 15. The rise to maximum was somewhat unsteady, but a smoothed curve agreed closely with the mean curve given in *A.J.* no. 358, and the corrections to the ephemeris founded on the elements therein given are only +1 day and −1 day, respectively.

Marengo, Ill., 1896 *April* 21.

OBSERVATIONS OF COMET *b* 1896 (*SWIFT*),

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY ARTHUR J. ROY.

1896 Albany M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
April 22 8 22 15	1	8	+0 11.64	+3 29.9	3 30 22.99	+34 3 52.3	9.706	0.768
23 8 30 31	2	10	+0 36.45	+1 2.0	3 27 50.86	+36 40 24.2	9.712	0.777
26 8 22 45	3	10	+0 30.09	+2 14.5	3 18 10.86	+43 56 54.4	9 749	0.776

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 30 11.32	+0.03	+34 0 12.6	+9.8	Bonn VI, 682, Paris 4238, Leiden Zones
2	3 27 14.45	−0.04	+36 39 12.4	+9.8	Lund, Zones 117 and 121
3	3 17 41.01	−0.24	+43 54 30.1	+9.8	Deichmüller, Bonn A.G. Catal. 2844

Nucleus quite diffuse; $\Delta\alpha$ measured micrometrically.

OBSERVATIONS OF COMET *b* 1896 (*SWIFT*),

MADE AT THE U.S. NAVAL OBSERVATORY,

BY ASSISTANT ASTRONOMER GEORGE A. HILL.

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

1896 Washington M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
April 26 $8^h\ 10^m\ 40^s$	1	20 , 4	$-3^m\ 2^s.69$	$-8'\ 37''.1$	$3^h\ 18^m\ 10^s.49$	$+43°\ 52'\ 25''.6$	9.781	0.741

Mean Place for 1896.0 of Comparison-Star.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	$3^h 21^m 13^s.40$	$-0^s.22$	$+44°\ 0'\ 52''.5$	$+10''.2$	Deichmüller, Bonn A.G. Catal. 2906

ELEMENTS AND EPHEMERIS OF COMET *c* 1895 (*PERRINE*),

BY R. G. AITKEN.

The following elements and ephemeris are based upon Mr. PERRINE's observations of Nov. 17, Dec. 7, 1895, and March 10, 1896 (Mt. Hamilton M.T.).

ELEMENTS.

$$T = 1895 \text{ Dec. } 18^d.32670 \text{ Greenwich M.T.}$$

$$\left.\begin{aligned} \omega &= 272°\ 40'\ 23''.4 \\ \Omega &= 320\ \ 30\ \ 47.6 \\ i &= 141\ \ 36\ \ 39.5 \end{aligned}\right\} 1896.0$$

$$\log q = 9.283259$$

Residuals for the middle place (O−C):

$$\Delta\lambda \cos\beta = +1''.5 \quad , \quad \Delta\beta = +1''.9.$$

CONSTANTS FOR THE EQUATOR, 1896.0.

$$x = [9.963187]r \sin(\ 35°\ 31'\ 42''.1 + v)$$

$$y = [9.996428]r \sin(128\ \ 42\ \ \ 5.4 + v)$$

$$z = [9.618080]r \sin(235\ \ \ 5\ \ 54.1 + v)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1896	App. α	App. δ	log r	log Δ	Br.
	h m s	° ′			
May 8.5	18 46 45	+20 36.5			
12.5	18 38 58	21 23.6	0.4584	0.3552	0.057
16.5	18 30 50	22 5.4			
20.5	18 22 27	22 41.3	0.4747	0.3619	0.051
24.5	18 13 53	23 10.7			
28.5	18 5 14	23 33.7	0.4902	0.3720	0.045
June 1.5	17 56 36	23 49.9			
5.5	17 48 4	23 59.5	0.5049	0.3858	0.040
9.5	17 39 43	24 2.6			
13.5	17 31 39	23 59.6	0.5189	0.4027	0.035
17.5	17 23 56	23 50.9			
21.5	17 16 37	23 36.9	0.5322	0.4226	0.030
25.5	17 9 46	23 18.3			
29.5	17 3 23	22 55.8	0.5450	0.4441	0.025
July 3.5	16 57 31	22 29.9			
7.5	16 52 9	+22 1.1	0.5572	0.4679	0.021

NEW ASTEROIDS.

Professor KREUTZ has communicated the positions, for mean equinox of 1855.0, of two small planets found by Prof. WOLF on photographic plates taken at Heidelberg, April 21, at $10^h\ 19^m$, mean time.

CQ	$11\frac{1}{2}^{M}$	$\alpha = 13^h\ 15^m.3$,	$\delta = +3\ 33.$	Daily motion, -54^s in α, and 6′ northward.
CR	$11\frac{1}{2}$	$\alpha = 13\ 26.2$,	$\delta = +7\ 40.$	Daily motion, -60^s in α, and 1′ northward.

ADALBERT KRUEGER.

Professor Dr. ADALBERT KRUEGER, Editor of the *Astronomische Nachrichten*, and Director of the Royal Prussian Observatory at Kiel, died there on April 21, an hour before midnight. For some years his health had been delicate, and of late he had suffered much; but his end was peaceful and calm.

For sixteen years he had conducted the *Nachrichten* with signal ability; maintaining its high character as a center for astronomical research and information of the highest order, and even raising, whenever possible, its tone of scientific dignity, impartiality and judicious discrimination. By an especial agreement, made in May, 1880, between the Prussian Ministry of Public Instruction, the Council of the *Astronomische Gesellschaft*, and himself while Director of the Observatory at Gotha, it was provided that he should be transferred to the Observatory at Kiel, and there assume charge of the *Nachrichten*, from the beginning of its hundredth volume; — continuing the publication with the scientific support and cooperation of the Council, especially in judgement relative to communications, and the technical questions of editorship, to such extent as he might find desirable in any case. Moreover, Prof. KRUEGER was charged, on assuming the control, with the duty of obtaining the views of the Council as to the principles, scientific and technical, to be established for guiding his policy.

How admirably Prof. KRUEGER has filled the important position thus assigned him, is well known to astronomers. He has brought to his task a critical acumen, a judicious tact, and a kindly spirit, — a combination which has resulted to the advantage of astronomy in many countries.

This is neither the time nor the place to give any detailed history of KRUEGER's career, or any enumeration of his researches. A few words must suffice at present.

He was born in 1832 at Marienburg in Prussia; and, after pursuing his academic studies, became at the age of 21 years assistant to ARGELANDER in Bonn, who had then been engaged for somewhat more than a year upon the observations for his *Durchmusterung*. SCHÖNFELD had become an assistant a few months earlier; and the part in the work accomplished by these two young men proved so important that ARGELANDER insisted upon placing their names, with his own, upon the title-pages of the great work.

The spirit and influence of the master was naturally transfused into the pupils, and their subsequent services to astronomy were largely in the directions to which his guidance had naturally led. More even than any other of his pupils, they followed in the paths in which he had been a pioneer, and pursued them with the same zeal and thoroughness of which he had afforded so marked an example.

At Bonn KRUEGER was also active in the discovery, observation and computation of variable stars. Later, after a happy union, only now interrupted, with the daughter of his principal and teacher, he was appointed to the direction of the Observatory at Helsingfors; and there, in the years 1869 to 1876, he carried on the observations of the zone 55° to 65° for the Catalogue of the *Astronomische Gesellschaft*; these being completed with the same instrument, between 1877 and 1880, after his removal to Gotha, to which observatory he had meanwhile been appointed. Thence he was transferred to Kiel, to take the direction of the *Nachrichten*. The *A.G.* zone undertaken by him was the first completed of the whole series, although the Catalogue itself, from Boss's Zone, may have been finished a little sooner.

Although his life was thus largely occupied with labors upon the *Durchmusterung*, the Zone and Catalogue for the *Astr. Gesellschaft*, and the management of the *Astron. Nachrichten*, his other services to astronomy were numerous and varied. They comprised researches upon variable stars — determinations of stellar parallax — an elaborate determination of the stars in the cluster *h Persei*, observed with the Bonn heliometer between October 1860 and March 1862, and computed at Helsingfors, where they were published in 1865, — numerous computations of planets, comets, etc. The large proper motion ($2''.84$ gr. c.) of the star Groombridge 34 was also first detected by him.

He leaves the record of a useful and disinterested life; and is lamented by a large circle of astronomers, to whom his character had justly endeared him.

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PUBLISHED IN BOSTON, TRI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed May 9.*

THE
ASTRONOMICAL JOURNAL.
No. 375.

VOL. XVI. BOSTON, 1896 MAY 22. NO. 15

OBSERVATIONS OF VARIABLE STARS OF SHORT PERIOD,

BY EDWIN F. SAWYER.

2279. *T Monocerotis.*

In No. 2660 of the *A.N.*, I published a discussion of my observations on this star made during the years 1881–1883. The period from these observations was found to be 26.97 days. From the mean light-curve formed and light-scale adopted all the times of maximum and minimum up to and including the years 1881 and 1890 have been determined and published. The publication of Dr. CHANDLER's Second Catalogue has caused me to form a new mean light-curve, based on his elements which he considers nearly definitive, and using the observations, 181 in number, made during the years 1890 to 1894 inclusive. From this new light-curve the times of maximum and minimum for the years 1891 to 1894 have been deduced, and are given below. It appears that the increase occupies 7.42 days, and the decrease 19.58 days. The decrease is slow, and somewhat irregular, there being a distinct bend in the curve about 11 days after maximum. The star remains at maximum about 0.8 of a day, and at minimum about 2.5 days, with a fluctuation in light of a step or two at the maximum and minimum brightness.

The flatness of the curve at minimum precludes a sharp determination of this phase. The rise from minimum appears somewhat sharper than found by Dr. CHANDLER.

Observed Maxima			Observed Minima		
E.	Boston M.T.	wt.	E.	Boston M.T.	wt.
	d			d	
242	1891 Oct. 31.57	2	242	1891 Oct. 23.57	1
243	Nov. 27.74	3	243	Nov. 19.55	1
244	Dec. 23.95	3	244	Dec. 16.89	1
245	1892 Jan. 20.93	3	245	1892 Jan. 12.93	3
246	Feb. 15.76	3	246	Feb. 8.32	3
247	Mar. 13.96	5	247	Mar. 5.75	3
248	Apr. 9.31	1	248	Apr. 3.42	5
255	Oct. 15.99	1	249	30.94	1
256	Nov. 11.84	2	257	Dec. 1.82	2
257	Dec. 9.14	5	258	27.08	2
258	1893 Jan. 5.18	3	259	1893 Jan. 24.02	4
259	Feb. 1.38	2	260	Feb. 18.87	6
260	27.92	2	261	Mar. 18.87	7
261	Mar. 27.03	3	262	Apr. 15.33	5
269	Oct. 28.54	4	270	Nov. 19.22	5
270	1893 Nov. 24.23	3	271	1893 Dec. 14.56	5
271	Dec. 22.14	6	272	1894 Jan. 10.41	6
272	1894 Jan. 17.45	2	273	Feb. 6.02	10
			274	Mar. 4.92	10
			275	Apr. 1.71	6
			276	30.13	1

The mean yearly residuals are as follows:

Maximum				Minimum			
Year	Epoch	O—C	wt.	Year	Epoch	O—C	wt.
		d				d	
1891–2	245	+0.270	20	1891–2	245	+0.752	18
1892–3	258	+0.089	18	1892–3	259	−0.330	26
1893–4	270	−0.337	15	1893–4	273	+0.391	43
Mean	258	+0.007	18		259	+0.271	29

2676. *U Monocerotis.*

The observations on this star number 40, and extend from 1893 November 28 to 1894 May 3. Maxima were passed 1894 January 7, February 18 and April 5, showing intervals of 42 and 46 days respectively. Minima were reached 1893 December 14, 1894 January 29 and March 20, the intervals being 46 and 50 days respectively. All the maxima and minima were quite bright.

6189. *U Ophiuchi.*

The following minima of this star have been determined since 1891. The times have all been calculated by means of the mean light-curve by ARGELANDER's method, and the comparisons in the O—C column are with Dr. CHANDLER's latest elements given in his Second Catalogue.

Observed Minimum					
Epoch	Boston M.T.		Light Equat.	wt.	O—C
	d	h m	m		m
4798	1892 July 23	9 34.6	+5.3	3	+24.1
4835	Aug. 23	9 40.5	+2.1	1	−18.0
5213	1893 July 6	10 28.0	+6.8	2	+ 1.6
5684	1894 Aug. 5	10 53.1	+4.2	4	− 3.1

6404. *Y Ophiuchi.*

The following maxima and minima of this star have been deduced since my list published in no. 272 of the *A.J.* The large and increasing minus residuals indicate a further correction to my elements, which were given in the same number of the Journal. The following corrections should be made:

No. 272 *A.J.*, page 63, min. epoch 130, for Sept. read Oct. Epochs 146 and 147 for June read July.

Observed Maxima			Observed Minima		
E.	Boston M.T. d	wt.	E.	Boston M.T. d	wt.
207	1892 May 19.53	1	207	1892 May 13.43	1
209	June 22.34	3	208	29.55	3
210	July 9.53	1	209	June 16.83	2
211	26.12	4	211	July 20.20	6
212	Aug. 12.93	3	212	Aug. 5.65	1
213	30.07	2	213	23.52	7
214	Sept. 15.27	2	214	Sept. 10.44	4
215	Oct. 2.67	1	215	27.12	7
216	20.90	1	216	Oct. 12.82	2
229	1893 May 31.97	2	228	1893 May 7.44	1
230	June 15.21	1	229	23.45	2
231	July 3.77	2	231	June 30.39	2
232	20.79	4	232	July 15.06	3
233	Aug. 5.96	1	233	31.78	3
235	Sept. 10.13	4	234	Aug. 17.82	4
236	26.52	1	235	Sept. 4.62	6
237	Oct. 14.48	2	236	20.32	1
238	Nov. 1.35	1	237	Oct. 7.58	6
249	1894 May 7.50	1	251	1894 June 6.45	2
250	25.45	3	252	22.25	4
251	June 10.55	1	253	July 8.66	5
252	27.84	1	254	27.24	3
254	Aug. 1.42	2	255	Aug. 11.84	5
255	19.33	3	256	28.64	2
256	Sept. 4.08	1	257	Sept. 16.27	1
257	22.40	4	258	Oct. 3.40	6
258	Oct. 8.71	1	259	20.47	2
259	26.76	2			

The observations number 146.

The mean yearly residuals are as follows:

Maximum				Minimum			
Year	Epoch	O—C d	wt.	Year	Epoch	O—C d	wt.
1892	212	−0.229	18	1892	212	−0.116	33
1893	233	−0.542	18	1893	233	−0.308	28
1894	254	−0.420	19	1894	255	−0.553	30
Mean	233	−0.397	18		233	−0.326	30

6573. *Y Sagittarii.*

The observations on this star during 1894 number 61, and extend from May 29 to November 3. From these observations the following maxima and minima have been determined by use of the mean light-curve.

Observed Maxima			Observed Minima		
E.	Boston M.T. d	wt.	E.	Boston M.T. d	wt.
486	1894 May 31.64	1	486	1894 May 30.28	1
487	June 6.64	1	487	June 4.25	3
490	23.64	1	490	21.98	3
492	July 5.41	1	491	27.11	1
495	22.40	1	492	July 2.95	3
496	28.41	2	493	8.78	2
497	Aug. 3.38	1	496	26.00	2
498	8.76	1	497	Aug. 1.23	1
500	20.50	2	498	6.90	3
501	25.78	1	500	18.74	2
502	Sept. 1.03	1	501	24.25	2
503	6.33	1	506	Sept. 22.04	4
506	24.53	2	507	27.97	2
507	29.89	2	510	Oct. 14.96	1
508	Oct. 5.34	3	511	21.11	2
510	17.19	2	512	27.26	1
512	28.30	1	513	Nov. 1.52	2
513	Nov. 3.36	2			

The mean yearly residuals are

1894 Epoch Maximum 500 O—C ±0.000 d Weight 26.
Epoch Minimum 500 O—C −0.036 Weight 35.

In determining the times of minimum I have used the value 1.94 days, the duration of increase as found from my mean light-curve, instead of 1.80 days given in Dr. CHANDLER's elements, the residuals coming out much closer by using the former instead of the latter value.

6984. *U Aquilae.*

The observations on this star number 64, and extend from 1894 June 1 to December 3. From these observations the following maxima and minima have been determined by means of the mean light-curve, using YENDELL's elements, and, applying the apparent corrections found from my previous observations, and given in no. 323 of the *A.J.* In my former communication the value 2.12 days for $M-m$ found from my mean light-curve, instead of YENDELL's value 2.25 days, was used. In the results given below, however, YENDELL's value has been used as preferable to mine. The still large minus residuals would indicate a further correction to the elements possibly of the nature of a periodic inequality.

Observed Maxima			Observed Minima		
E.	Boston M.T. d	wt.	E.	Boston M.T. d	wt.
400	1894 May 30.11	1	401	1894 June 3.77	2
401	June 5.97	1	404	26.26	2
403	20.79	3	405	July 2.53	2
405	July 4.60	1	406	9.31	2
408	25.73	2	408	22.40	1
409	Aug. 1.59	2	409	30.53	2
410	8.53	1	410	Aug. 6.64	3
412	23.00	3	412	20.61	3
413	29.41	1	413	27.80	1
414	Sept. 4.76	1	417	Sept. 24.64	4

Observed Maxima			Observed Minima		
E.	Boston M.T.	wt.	E.	Boston M.T.	wt.
416	1894 Sept. 19^{d}.37	2	418	1894 Oct. 1^{d}.83	2
417	26.68	2	419	9.19	1
418	Oct. 4.29	2	420	16.05	1
420	18.31	3	421	22.26	1
421	26.03	2	422	29.83	1
422	Nov. 1.14	3	423	Nov. 5.72	1
424	15.54	1	425	19.25	1
425	22.39	1	427	Dec. 3.23	1
426	29.37	1			

The mean yearly residuals are

1894 Epoch Maximum 414 O−C −0^{d}.267 Weight 33.
Epoch Minimum 414 O−C −0.323 Weight 31.

7149. *S Sagittae.*

The observations on this star during 1894 extend from May 24 to 1895 January 3, and number 125. From these observations the following minima have been determined by use of the mean light-curve.

Observed Maxima			Observed Minima		
E.	Boston M.T.	wt.	E.	Boston M.T.	wt.
761	1894 May 29^{d}.48	1	775	1894 Sept. 23^{d}.61	4
762	June 6.08	3	776	Oct. 2.83	1
764	23.96	1	777	11.02	3
765	July 2.00	3	778	19.42	3
766	9.38	1	779	27.60	3
768	27.68	2	780	Nov. 4.66	3
769	Aug. 4.28	2	781	13.32	2
770	12.62	2	782	21.34	3
771	21.67	4	783	30.30	3
772	30.37	2	785	Dec. 16.41	2
773	Sept. 7.62	1	786	24.74	2
774	15.65	1	787	1895 Jan. 2.74	3

The mean residuals for 1894 are

Epoch Minimum 773 O−C −0^{d}.070 Weight 55.

7437. *X Cygni.*

Before the announced variability of this star by Dr. Chandler in 1886 he had requested me to observe it for the purpose of confirmation. I began observations 1886 November 29, and by December 4 the variability of the star had been fully established. The observations were continued during the years 1886 to 1889 inclusive, but press of other work has prevented until now the reduction of the material for publication. My results in manuscript, however, had been furnished Mr. Yendell for an investigation he was engaged in regarding some peculiarities in the light fluctuations which he suspected to exist. These results, together with those obtained during the year 1894, and given below, are for the first time published. A mean light-curve was formed from the 237 observations obtained previous to 1894, using Dr. Chandler's latest elements given in his Second Catalogue. A comparison of my observations with these elements given below indicates a correction of −0^{d}.0029 to the period, and −0^{d}.25 to the epoch of maximum. The rise from minimum as shown by the residuals appears somewhat sharper than found by Dr. Chandler, or about 6^{d}.1 instead of 6^{d}.8. The flatness of the curve at minimum, and a fluctuation of 2 or 3 steps prevents, however, a sharp determination of this phase.

Observed Maxima			Observed Minima		
E.	Boston M.T.	wt.	E.	Boston M.T.	wt
3	1886 Nov. 28^{d}.76	5	4	1886 Dec. 7^{d}.98	1
4	Dec. 14.83	5	5	21.82	4
5	30.44	3	6	1887 Jan. 9.31	3
6	1887 Jan. 16.92	2	7	25.62	1
15	June 13.45	5	15	June 7.92	2
16	29.71	3	16	23.32	4
17	July 15.71	4	17	July 9.69	4
19	Aug. 18.10	3	18	29.00	1
20	Sept. 3.65	2	19	Aug. 11.49	5
21	18.94	3	20	27.91	1
22	Oct. 5.67	3	21	Sept. 13.40	7
23	21.90	1	22	28.66	2
24	Nov. 7.52	5	23	Oct. 16.05	5
25	23.76	1	24	Nov. 1.58	5
26	Dec. 9.92	3	25	18.00	5
28	1888 Jan. 12.17	4	26	Dec. 5.06	4
29	28.99	2	27	20.25	5
36	June 8.43	3	28	1888 Jan. 4.25	2
37	24.56	1	29	23.97	2
38	July 11.43	3	36	May 31.43	2
39	27.75	2	37	June 17.01	2
40	Aug. 11.96	2	38	July 3.72	4
41	27.88	2	40	Aug. 6.72	3
42	Sept. 13.80	2	41	22.21	2
43	30.11	2	42	Sept. 8.16	1
45	Nov. 2.19	4	43	23.41	3
47	Dec. 4.78	2	44	Oct. 9.96	2
48	21.60	6	45	26.32	3
50	1889 Jan. 22.76	3	47	Dec. 1.34	2
59	June 19.66	5	49	1889 Jan. 1.36	4
60	July 5.92	2	50	18.13	1
61	23.32	2	60	June 29.31	3
63	Aug. 23.94	6	61	July 15.71	3
65	Sept. 25.19	1	62	Aug. 1.05	1
66	Oct. 12.01	3	63	16.21	1
68	Nov. 13.63	5	64	Sept. 3.45	2
69	Dec. 1.47	1	65	19.24	2
70	16.67	1	67	Oct. 22.59	3
71	1890 Jan. 2.08	1	69	Nov. 24.79	3
170	1894 June 13.40	1	70	Dec. 9.90	3
171	28.72	5	71	26.95	6
173	July 30.91	3	72	1890 Jan. 10.94	1
174	Aug. 16.77	3	170	1894 June 6.21	5
175	Sept. 2.65	2	171	22.73	4
176	18.43	3	172	July 9.22	4
177	Oct. 5.03	3	173	25.00	4
178	21.37	3	174	Aug. 11.02	4
179	Nov. 6.52	3	175	26.71	6
180	22.50	4	177	Sept. 28.41	7
181	Dec. 9.12	3	178	Oct. 14.63	9
182	25.51	4	179	31.61	7
183	1895 Jan. 11.25	1	180	Nov. 1.61	6
184	27.49	2	181	Dec. 5.12	6
			182	19.53	7
			183	1895 Jan. 4.89	4
			184	22.26	4

The mean yearly residuals are as follows:

Maximum.				Minimum			
Year	Epoch	O—C	wt.	Year	Epoch	O—C	wt.
		d				d	
1887	18	−0.077	54	1887	19	+0.623	63
1888	42	+0.056	32	1888	43	+0.530	29
1889	65	−0.200	27	1889	66	+0.188	28
1894	177	−0.705	40	1894	177	+0.003	77
Mean	76	−0.231	38		76	+0.336	49

7483. *T Vulpeculae.*

From my observations, 418 in number, of this star, extending from 1887 May 14 to 1895 January 17, the following times of maxima and minima have been determined, using the elements published in Dr. Chandler's Second Catalogue; this list being a continuation of the one published in no. 169 of the *A.J.*

Observed Maxima			Observed Minima		
E.	Boston M.T.	wt.	E.	Boston M.T.	wt.
	d			d	
132	1887 June 12.21	1	126	1887 May 14.20	1
133	15.69	1	128	23.44	1
135	24.77	2	132	June 9.17	2
136	28.89	2	133	13.41	2
138	July 8.02	2	134	18.86	1
139	12.43	2	136	27.73	1
140	15.92	1	140	July 14.40	1
142	25.71	1	141	20.07	2
145	Aug. 8.01	2	147	Aug. 16.13	1
146	12.19	2	148	20.10	1
147	16.92	2	152	Sept. 6.71	1
149	25.72	1	153	11.50	1
151	Sept. 3.27	1	154	15.83	1
152	8.25	2	155	19.68	3
154	16.94	2	156	24.77	1
156	25.76	1	159	Oct. 7.73	1
160	Oct. 13.49	1	160	12.42	1
161	18.34	1	161	16.72	2
164	31.25	1	163	24.70	1
165	Nov. 4.50	1	164	29.90	1
166	9.01	1	165	Nov. 3.61	2
167	13.57	1	166	7.77	3
168	18.08	1	167	13.22	1
169	22.55	1	168	16.87	2
171	Dec. 1.39	1	169	21.00	1
172	5.75	2	172	Dec. 3.99	1
174	14.41	1	174	13.37	2
175	18.98	1	175	17.55	1
176	23.12	1	176	22.05	2
179	1888 Jan. 5.73	1	179	1888 Jan. 3.90	1
180	10.20	1	181	12.90	1
181	14.59	1	215	June 12.56	1
182	18.60	1	218	25.36	1
214	June 9.34	1	219	30.17	1
215	13.43	1	220	July 4.15	1
216	17.95	1	221	8.55	1
220	July 5.42	1	222	12.95	1
221	10.12	1	226	30.99	2
222	14.43	1	227	Aug. 4.38	1
226	Aug. 1.38	2	229	13.17	1
228	10.40	1	232	26.38	2
229	1888 Aug. 14.42	1	233	1888 Aug. 31.33	2
232	27.72	1	236	Sept. 13.33	1
233	Sept. 2.08	1	239	26.73	1
234	5.60	1	240	30.69	1
238	23.32	1	242	Oct. 9.95	2
239	28.12	2	247	31.80	3
240	Oct. 2.39	1	254	Dec. 2.11	2
245	24.74	2	258	19.87	1
247	Nov. 2.38	1	259	24.31	2
248	6.99	1	260	28.27	1
254	Dec. 3.22	1	261	1889 Jan. 1.91	1
258	21.30	2	265	19.33	1
259	25.54	1	299	June 19.88	1
260	30.26	1	300	23.83	2
261	1889 Jan. 3.56	1	301	28.77	1
301	June 30.15	1	303	July 7.66	1
305	July 17.48	2	305	16.39	1
307	26.43	1	307	25.13	1
309	Aug. 1.39	1	314	Aug. 24.34	1
313	22.07	1	315	30.25	2
319	Sept. 18.44	1	319	Sept. 16.57	1
320	22.29	1	326	Oct. 17.44	1
321	27.03	1	327	22.42	1
324	Oct. 10.26	1	333	Nov. 17.89	2
325	14.61	1	334	21.92	1
326	18.75	1	341	Dec. 22.39	2
327	23.27	1	342	27.19	2
332	Nov. 14.45	2	343	31.28	1
333	19.05	1	345	1890 Jan. 9.65	1

Observed Maxima			Observed Minima		
E.	Boston M.T.	wt.	E.	Boston M.T.	wt.
	d			d	
338	1889 Dec. 11.22	1	565	1889 Sept. 12.32	1
341	24.22	1	566	16.39	2
342	28.72	1	567	21.58	1
565	1892 Sept. 12.79	1	568	24.87	1
566	17.46	1	569	29.66	2
567	21.73	1	570	Oct. 3.59	1
568	26.49	2	572	13.15	1
569	30.53	2	574	22.35	1
571	Oct. 10.09	2	576	30.27	1
572	14.11	2	578	Nov. 8.31	1
574	22.96	2	581	21.36	2
577	Nov. 5.24	1	584	Dec. 4.87	1
578	9.98	1	585	9.25	1
580	18.22	1	587	18.24	1
581	23.27	2	588	22.25	1
585	Dec. 10.50	2	631	1893 July 1.41	1
586	15.49	2	632	5.62	2
632	1893 July 7.61	1	633	10.39	1
633	11.63	1	635	19.82	1
635	20.53	2	636	24.38	1
636	24.60	1	639	Aug. 5.76	1
638	Aug. 2.61	2	640	10.46	1
639	7.34	1	641	14.41	2
641	16.01	2	646	Sept. 5.93	1
642	20.43	1	647	10.62	2
644	28.84	2	651	29.54	1
645	Sept. 2.74	2	652	Oct. 2.68	1
646	7.18	1	653	8.36	1

OBSERVED MAXIMA

E.	Boston M.T.	wt.
	d	
647	1893 Sept. 11.78	3
648	16.31	1
652	Oct. 4.08	1
653	8.42	1
654	12.50	1
655	17.49	1
658	30.97	2
659	Nov. 3.95	1
660	8.93	1
664	26.48	1
665	30.64	1
671	Dec. 27.41	2
672	31.64	1
706	1894 May 31.28	1
707	June 4.74	2
709	13.64	1
711	22.69	1
712	26.75	1
713	July 1.59	2
714	5.77	1
719	28.08	1
720	Aug. 1.63	1
721	6.02	3
722	10.52	2
724	19.31	2
725	23.47	2
726	28.03	3
728	Sept. 6.28	1
729	11.07	2
731	19.29	1
732	23.79	3
733	28.36	3
734	Oct. 2.70	1
735	7.11	2
736	1894 Oct. 11.28	2
737	15.83	3
738	20.26	1
740	29.48	1
741	Nov. 2.56	2
742	7.49	1
743	11.59	2
744	16.20	2
745	20.26	1
746	25.25	1
747	29.23	1
748	Dec. 3.72	2
750	12.58	1
751	17.49	1
752	21.46	2
753	25.84	2
754	30.25	1
755	1895 Jan. 3.92	2
758	17.47	1

OBSERVED MINIMA

E.	Boston M.T.	wt.
	d	
654	1893 Oct. 11.32	2
655	15.96	1
658	29.67	1
659	Nov. 3.42	1
660	6.77	2
661	11.25	2
662	15.25	1
664	24.63	1
665	29.33	1
666	Dec. 3.69	2
667	7.34	2
668	12.05	3
669	17.65	1
671	25.65	3
672	30.44	1
673	1894 Jan. 2.47	2
674	7.75	2
707	June 3.44	1
708	8.48	1
711	21.39	2
712	25.42	1
713	29.84	1
714	July 4.38	1
715	8.81	2
718	23.13	1
719	26.82	2
720	31.67	1
721	Aug. 1.59	1
724	18.09	2
725	22.48	2
726	26.42	2
727	Sept. 1.13	1
729	9.31	1
732	22.93	2
733	1894 Sept. 26.68	1
734	Oct. 1.68	1
735	6.19	1
736	10.10	2
737	14.31	1
738	19.62	2
739	23.71	1
740	27.89	3
741	Nov. 1.20	2
742	5.69	2
743	11.22	1
745	19.25	1
746	23.22	1
747	28.17	2
748	Dec. 1.71	1
749	6.35	2
750	10.90	1
751	15.63	1
752	19.72	3
753	24.19	1
754	29.24	1

The mean yearly residuals are given in the table below.

MAXIMUM				MINIMUM			
Year	Epoch	O—C	wt.	Year	Epoch	O—C	wt.
		d				d	
1887	158.0	−0.036	40	1887	156.0	−0.158	43
1888	236.5	−0.025	27	1888	237.0	−0.178	30
1889	322.5	−0.082	19	1889	321.0	−0.230	22
1892	574.0	−0.145	22	1892	575.5	−0.105	18
1893	649.5	−0.228	33	1893	654.5	−0.365	44
1894	733.5	−0.274	65	1894	732.5	−0.297	55
Mean	445.5	−0.132	34		446.0	−0.222	35

Brighton, Mass., 1896 *Feb.* 7.

FINDING EPHEMERIS FOR COMET 1889 V (*BROOKS*).

(Continued from page 31,)

BY CHARLES LANE POOR.

Gr. M.T.	App. α	App. δ	log. Δ	Br.
1896	h m s	° ′ ″		
May 12.5	21 42 3.6	−20 54 34	0.33479	0.33
16.5	47 29.3	−20 35 54		
20.5	52 44.5	−20 17 59	0.30889	0.38
24.5	21 57 48.6	−20 0 54		
28.5	22 2 40.8	−19 44 19	0.28205	0.44
June 1.5	7 20.4	−19 28 48		
5.5	11 46.1	−19 14 20	0.25437	0.53
June 9.5	22 15 46.8	−19 1 3		
13.5	19 51.3	−18 49 4	0.22602	0.61
17.5	23 28.6	−18 38 29		
21.5	26 47.4	−18 29 24	0.19726	0.72
25.5	29 46.7	−18 21 52		
29.5	22 32 25.1	−18 15 58	0.16840	0.84

Johns Hopkins University, 1896 *May* 10.

OBSERVED MAXIMA AND MINIMA OF VARIABLE STARS.

BY PAUL S. YENDELL.

806. o *Ceti.*

I have thirty-nine observations of *Mira*, from 1895 November 16 to 1896 March 12. When first observed, the star's light was estimated as $8^{M}.8$. The increase, as indicated by my observations, was regular, no fluctuations of an amplitude exceeding the probable errors of observation having been noticed. From 1896 January 16 to February 12, the star remained very nearly constant in light, the mean of twelve observations made in this interval being $3^{M}.86$. A maximum is indicated on 1896 January 28. At the last observation, the star's light had decreased to $5^{M}.1$.

3493. *R Leonis.*

Twenty-eight observations of *R Leonis*, from 1895 November 27 to 1896 March 14, show a very normal light-curve, with a maximum indicated on 1896 January 12, at a magnitude of 6ᴹ.4, at which the star's light remained sensibly stationary from January 5 to 18. At the last observation it had decreased to 8ᴹ.5.

I have also an incomplete series of observations of the maximum preceding the above, badly broken up by weather. There are nine observations, from 1895 January 27 to March 28. Though these observations show no maximum, they go to show that this phase took place at a date not earlier than March 3, up to which time they show an uninterrupted increase from 6ᴹ.9 to 5ᴹ.4. From March 3 to March 28, no observation was obtained, but when observed at the latter date, the star was again found at 5ᴹ.4; as it seemed certain that the maximum must have been past, I discontinued the observations. In view, however, of the publication of other more or less incompletely observed maxima, I have thought the foregoing report to be not out of place

5955. *R Draconis.*

Nine observations of this star, from 1895 December 14 to 1896 February 1, show a rapid increase from 8ᴹ.7 to a sharply marked maximum of 6ᴹ.4, which is indicated on January 19, and an equally rapid decrease to 7ᴹ.1.

7751. *W Cygni.*

This star was observed twenty-four times, from 1895 April 23 to December 22. A minimum of 6ᴹ.8 is indicated on June 21, and a maximum of 5ᴹ.7 on August 30.

8068. *S Lacertae.*

Eleven observations, from 1895 December 16 to 1896 February 20, show a very well-defined maximum of 8ᴹ.1 on 1896 January 10. The light at the first observation was 8ᴹ.8, and at the last it had decreased to 9ᴹ.3. Both increase and decrease appear to have been regular and steady.

Dorchester, Mass., 1896 March 16.

ECLIPSES AND CHRONOLOGY,

BY W. T. LYNN.

I wish merely for a few lines of the *Astr. Journal* in reference to the solar eclipse of A.D. 393 November 20, which Prof. STOCKWELL thinks obliges us to bring the date of the death of THEODOSIUS the Great to one year earlier than that generally accepted, *i.e.* A.D. 395, in the month of January. That it occurred a few months after his victory over EUGENIUS in the north of Italy there is no doubt whatever. All the historians except ZOSIMUS speak of a great storm which occurred during the battle; he only says that the sun was eclipsed. From this, Prof. STOCKWELL concludes that the date was A.D. 393, when the sun was eclipsed in November 20. But the ecclesiastical historian SOCRATES states most distinctly that the battle took place early in the month of September, in itself a much more likely time for it; so that in all probability ZOSIMUS mistook an account of a storm (which doubtless produced darkness) for one of an eclipse. CLAUDIAN refers to the storm in these lines:

> "*Te propter gelidis Aquilo de monte procellis*
> *Obruit adversas acies, revolutaque tela*
> *Vertit in auctores et turbine reppulit hastas.*"

It seems to me, therefore, that the eclipse was in the winter preceding the last war of THEODOSIUS, and that we have no reason for shifting the date of his death from that generally accepted, A.D. 395. SOCRATES places it in January; and there would not have been time sufficient in those days for the events which he mentions, between the battle and the emperor's death, if the former event took place late in November.

FILAR-MICROMETER OBSERVATIONS OF COMET *c* 1895 (*PERRINE*),

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY ORMOND STONE.

1895 Charlottesville M.T.		✳	No. Comp.	☄ — ✳		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 26	17 5 39	1	2	. . .	−6 36.6	. . .	−4 24 35.4	. .	0.745
	17 19 39	2 . 3	25	−0 43.25	. . .	14 10 45.57	. . .	*n*9.630	. .
	17 39 29	2	2	. . .	+0 30.3	. . .	−4 25 11.4	. .	0.750
	17 59 21	2	30 . 2	−0 26.87	−0 10.1	14 10 51.42	−4 26 24.8	*n*9.590	0.752
27	18 6 27	4	20 . 4	+2 51.50	−0 41.6	14 11 29.82	−5 16 12.9	*n*9.579	0.759
28	17 50 21	5	20 . 4	+0 39.12	−5 16.6	14 18 21.89	−6 8 21.6	*n*9.600	0.759

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	14 8 59.07	+2.00	−4 17 41.6	−17.2	Dr. Becker, 2 observations
2	14 11 16.30	+1.99	−4 25 57.6	−17.1	Dr. Becker, 2 observations
3	14 11 37.36	+1.99	−4 20 30.4	−17.1	Dr. Becker, 2 observations
4	14 11 36.31	+2.01	−5 15 11.2	−17.1	Argentine Gen. Catalogue
5	14 17 40.75	+2.02	−6 2 48.1	−16.9	Bessel, Zone 239

OBSERVATIONS OF COMET *b* 1896 (*SWIFT*),

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY PROF. MARY W. WHITNEY AND CAROLINE E. FURNESS.

1896 Greenwich M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$		Obs.
			Δα	Δδ	α	δ	for α	for δ	
h m s			m s	′ ″	h m s	° ′ ″			
April 23 13 33 7	1	10	+0 35.81	+1 50.6	3 27 50.22	+36 41 12.8	9.714	0.782	F
27 13 58 8	2	10	+0 38.92	−4 15.2	3 14 8.54	+46 14 2.4	9.725	0.826	F
29 15 2 40	3	8	+2 2.06	−7 45.2	3 5 3.52	+50 24 29.5	9.609	0.896	F
30 14 11 46	4	5	+2 42.55	−1 5.3	3 0 17.56	+52 12 20.5	9.718	0.965	F
15 12 25	4	5	+2 29.62	+3 13.2	3 0 4.63	+52 16 39.0	9.573	0.906	W
May 4 14 37 55	5	8	−2 49.94	+6 21.2	2 37 44.29	+58 30 15.1	9.632	0.899	F
5 15 22 55	6	6	−3 19.76	−1 18.1	2 31 19.89	+59 50 1.4	9.397	0.925	F
6 14 10 2	7	10	+0 24.79	−3 32.0	2 25 13.81	+60 56 15.6	9.686	0.888	W
7 14 31 10	8	8	+1 34.08	+4 42.6	2 18 32.42	+62 4 52.3	9.589	0.907	F

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 27 14.45	−0.04	+36 39 12.4	+9.8	Lund A.G. Catal. Zones, 2 obs.
2	3 13 29.97	−0.35	+46 18 7.9	+9.7	Deichmüller, Bonn A.G. Catal. 2784
3	3 3 1.95	−0.49	+50 32 5.5	+9.2	Rogers, Cambridge A.G. Catal. 1395
4	2 57 35.58	−0.57	+52 13 17.0	+8.8	Rogers. Cambridge A.G. Catal. 1367
5	2 40 35.15	−0.92	+58 23 46.4	+7.5	Krueger, Helsingfors-Gotha A.G. Catal. 2515
6	2 34 40.69	−1.04	+59 51 12.5	+7.0	Krueger, Helsingfors-Gotha A.G. Catal. 2458
7	2 24 50.19	−1.17	+60 59 41.5	+6.1	Krueger, Helsingfors-Gotha A.G. Catal. 2302
8	2 16 59.61	−1.27	+62 0 4.4	+5.3	Krueger, Helsingfors-Gotha A.G. Catal. 2205

OBSERVATIONS OF COMET *b* 1896 (*SWIFT*),

MADE AT THE LICK OBSERVATORY, WITH THE 12-INCH EQUATORIAL,

BY WILLIAM J. HUSSEY.

1896 Mt. Hamilton M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
April 27 8 24 54	4	*d* 7, 12	+0 39.84	+3 55.8	3 13 42.85	+46 28 14.7	9.793	0.759
30 8 49 23	5	9, 6	+1 24.30	+6 37.6	2 59 13.14	+52 24 51.8	9.786	0.818
May 2 9 22 49	6	6	. . .	+1 43.4	. . .	+55 47 11.9	. .	0.871
9 34 13	6	*d*10	−0 4.79	. . .	2 48 16.21	. . .	9.699	. .

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
4	3 13 3.33	−0.32	+46 24 9.2	+9.7	Deichmüller, Bonn A.G. Catal. 2775
5	2 58 19.41	−0.57	+52 18 5.3	+8.9	Rogers, Cambridge A G. Catal. 1368
6	2 48 51.75	−0.75	+55 45 20.3	+8.2	Krueger. Helsingfors-Gotha A.G. Catal. 2628

NOTES. *d* denotes that Δα was measured directly with the micrometer. Except on April 30, clouds interfered more or less with the measures. On April 30, the comet was seen to have a slender tail, about 1½° long, proceeding from the central part of the coma, and closely resembling the tail of GALE's comet, 1894 II.

OBSERVATIONS OF COMET *b* 1896 (*SWIFT*),

MADE AT THE LICK OBSERVATORY,

BY R. G. AITKEN.

1896 Mt. Hamilton M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ
			s	′ ″	h m s	° ′ ″		
April 19 7 56 59	1	8 , 3	−31.61	+4 52.7	3 35 42.00	+26 19 26.3	9.718	0.702
20 7 47 28	2	7 . 6	− 6.13	−6 20.6	3 34 11.93	+29 0 53.6	9.730	0.684

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 36 13.49	+0.12	+26 14 21.9	+8.7	Paris III, 4351
2	3 31 17.96	+0.10	+29 7 5.1	+9.1	Micrometer-comparison with (3)
3	3 34 54.97	+0.10	+29 10 17.9	+9.1	Paris III, 4329

The measures on both nights were made through fog and necessarily at great hour-angles.

EPHEMERIS OF VARIABLES OF THE ALGOL-TYPE,

Greenwich Mean Time,

BY PAUL S. YENDELL.

		h
May		
23	*Y* Cygni	13
	δ Librae	13
	U Cephei	16
25	*U* Ophiuchi	21
	δ Librae	21
26	*Y* Cygni	12
	U Coronae	12
	U Ophiuchi	17
27	*U* Ophiuchi	13
28	*U* Ophiuchi	10
	U Coronae	16
29	*Y* Cygni	12
	S Cancri	23
31	*U* Ophiuchi	21
June		
1	*Y* Cygni	12
	δ Librae	20
2	*U* Coronae	10
	U Ophiuchi	10
	U Cephei	16
4	*Y* Cygni	12
5	*U* Ophiuchi	18
	U Coronae	21
6	δ Librae	12
	U Ophiuchi	15
7	*U* Ophiuchi	11
	Y Cygni	12
	U Cephei	15
8	*S* Cancri	11
June		
8	δ Librae	20
10	*Y* Cygni	12
	U Ophiuchi	19
11	*U* Ophiuchi	15
12	*U* Ophiuchi	11
	U Cephei	15
	U Coronae	18
13	δ Librae	12
	Y Cygni	12
15	δ Librae	20
	U Ophiuchi	20
16	*Y* Cygni	12
	U Ophiuchi	16
17	*U* Ophiuchi	12
June		
17	*U* Cephei	14
	S Cancri	23
19	*Y* Cygni	12
	U Coronae	16
20	δ Librae	11
21	*U* Ophiuchi	17
22	*Y* Cygni	12
	U Ophiuchi	13
	U Cephei	14
	δ Librae	19
23	*U* Ophiuchi	10
25	*Y* Cygni	12
26	*U* Coronae	14
	U Ophiuchi	18
June		
27	*S* Cancri	10
	δ Librae	11
	U Ophiuchi	14
	U Cephei	14
28	*U* Ophiuchi	10
	Y Cygni	11
29	δ Librae	19
July		
1	*Y* Cygni	11
	U Ophiuchi	18
2	*U* Cephei	13
	U Ophiuchi	15
3	*U* Ophiuchi	11

NEW ASTEROID.

The position of another small planet, found by Mr. CHARLOIS upon a photograph taken by him at Nice, has been communicated by Prof. KREUTZ.

CS. 12^M 1896 May 4, $10^h\ 7^m.0$ Nice M.T. $\alpha = 14^h\ 1^m\ 48^s$. $\delta = -3°\ 4'$. Daily motion -64^s and 3′ southward.

CORRIGENDUM.

The observations of *Mimas* published in no. 374, page 109, were made by Dr. E. O. LOVETT, and not by Prof. STONE as there printed, in the title and in the contents.

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PUBLISHED IN BOSTON, TRI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed May 22.*

THE

ASTRONOMICAL JOURNAL.

No. 376.

VOL. XVI. BOSTON, 1896 JUNE 4. NO. 16

ON CERTAIN SYSTEMATIC ERRORS IN THE RIGHT-ASCENSIONS OF THE FUNDAMENTAL STARS,

BY GEORGE C. COMSTOCK.

The conclusions reached by Professor NEWCOMB in the paper entitled "On the Variation of Personal Equation with the Magnitude of the Star Observed," *Astr. Journal*, no. 369, find an interesting confirmation in the observations made at the Washburn Observatory with my modified form of the Loewy prism apparatus. A detailed description of the instrument and the methods of employing it are contained in Vol. IX of the Publications of the Washburn Observatory, now nearly ready for distribution, and referring to that work for details I need state here only that the instrument furnishes measurements of the angular distance between stars approximately 120° apart. It is therefore analogous to the heliometer with reference to the kind of data which it furnishes, and shares with the latter the great advantage that its results depend solely upon micrometric observations of stars simultaneously seen in the field of the telescope.

A comparison of the measured distances with those computed from the tabular coordinates of the stars may be employed as a test of the presence of systematic errors in these coordinates, and the following lines relative to such an error depending upon the magnitudes of the stars were in print as a part of the Vol. IX above referred to, several weeks before the receipt of Professor NEWCOMB's paper.

"In 'A Determination of the Solar Parallax from Observations of *Mars*, made at the Island of Ascension in 1877, by DAVID GILL, LL.D.,' the author bases upon a comparison of his heliometer observations of stars with meridian determinations of their places the conclusion that, in general, chronographic determinations of the right-ascensions of faint stars make these right-ascensions relatively greater than those of brighter stars; *loc. cit.*, p. 78.

"It is apparent, that if this conclusion is well founded, the computed distance separating a pair of stars of different magnitudes will in general be greater than the true distance if the brighter star precedes the fainter star, and will be less than the true distance if the preceding star is fainter than the following one. I have therefore, at Dr. GILL's suggestion, examined the observations made with the reel to determine whether any effect of difference of stellar magnitude is shown in the comparison of the measured and computed distances. For this purpose I have employed the thirty-eight residuals, r, of the table at p. 181, arranged in the order of difference of stellar magnitude of the stars composing a pair, this difference being considered positive when the brighter star precedes the fainter.

"Giving equal weight to the result from each pair of stars, and taking the mean of groups of consecutive values, we obtain the following mean results, in which a positive sign for r indicates an excess of the computed over the observed value. M denotes the mean difference of magnitude, m the number of pairs, and n the number of observations in each mean value of r.

M	m	n	v
−2.2	8	162	−0″.25
−0.8	7	169	−0.09
0.0	8	176	−0.01
+0.4	7	118	+0.09
+1.7	8	130	+0.26

"The numbers in this table appear to me to confirm Dr. GILL's conclusion that the right-ascensions of the fainter stars are too great; and from a graphical adjustment of the data I find that between the second and seventh magnitudes this excess amounts to $0''.14 = 0^s.009$ per magnitude, for the right-ascensions here employed. *Cf.* the Cape Catalogue, 1885, p. xiv."

The residuals, r, above referred to, are the combined results of the comparison of about 800 observations of 38 pairs of stars, with tabular coordinates derived from the ephemerides and twenty of the principal modern catalogues, reduced to the system of the *Berliner Jahrbuch*. In respect of precision the adopted right-ascensions may be classed with those of the best determined *Hauptsterne*, since according to Dr. Auwers the probable error of the latter, for the epoch of the observations in question, is $\pm 0^s.014$. *Astr. Nach.*, No. 2714, while the discussion of my own observations furnishes as the probable error of a single right-ascension, $\pm 0^s.013$. The comparison of these right-ascensions with micrometric observations confirms quantitatively, and to a remarkable degree of approximation, the results of Prof. Newcomb and Dr. Gill.

After the adopted right-ascensions had been corrected for the effect of magnitude, as above determined, a comparison of the computed and observed distances appeared to indicate some periodic variation depending upon the right-ascensions of the stars, and this variation became much more conspicuous and unmistakable when the systems of right-ascension of the Nautical Almanac and the *Connaissance des Temps* were substituted for that of the *Berliner Jahrbuch*. The right-ascensions of the American Ephemeris differ so little from those of the *Berliner Jahrbuch* that no separate comparison was made with it.

The stars observed with the prism-apparatus were so near the equator that errors in the tabular declinations will produce no sensible effect upon the computed distances, and I therefore assume that the only effect upon the values of C − O which is to be attributed to the tabular places of the stars arises from errors in their right-ascensions having the form,

$$h\alpha = a\sin\alpha + b\cos\alpha + c\sin 2\alpha + d\cos 2\alpha$$

The effect of such errors is to produce in the computed distances errors represented by the series of terms,

$$ID = A\sin\alpha_0 + B\cos\alpha_0 + C\sin 2\alpha_0 + D\cos 2\alpha_0$$

where α_0 represents the half sum of the right-ascensions of the stars which determine the arc D and the several coefficients have the following values:

$$A = +\sqrt{3}b\ ,\ B = -\sqrt{3}a\ ,\ C = +\sqrt{3}d\ ,\ D = -\sqrt{3}c$$

Each of the 38 pairs of stars furnishes a residual, $e = \mathrm{C} - \mathrm{O}$ for the determination of the coefficients A, B, C, D, and a fifth quantity K, a constant difference between the measured and computed distances, and referring to Vol. IX for the individual observations and the derivation of the adopted coordinates of the stars, I give here the resulting equations for the determination of the five unknown quantities.

16 *Aquarii*	*o Orionis*	K	$+0.32\,A$	$+0.94\,B$	$+0.62\,C$	$+0.79\,D$	=	$+0.70$
β Piscium	19 *Monocerotis*		$+\ .70$	$+\ .72$	$+1.00$	$+\ .03$	=	$+\ .62$
f Piscium	23 *Hydrae*		$+\ .98$	$+\ .21$	$+\ .42$	$-\ .91$	=	$+\ .28$
B.D. −0°258	*ι Hydrae*		$+\ .99$	$+\ .11$	$+\ .22$	$-\ .98$	=	$-\ .58$
α Piscium	*α Leonis*		$+1.00$	$+\ .03$	$+\ .05$	-1.00	=	$+\ .48$
γ Ceti	*l Leonis*		$+\ .99$	$-\ .16$	$-\ .31$	$-\ .95$	=	$+\ .25$
α Ceti	*p² Leonis*		$+\ .97$	$-\ .24$	$-\ .47$	$-\ .88$	=	$+\ .50$
10 *Tauri*	*v Leonis*		$+\ .92$	$-\ .39$	$-\ .72$	$-\ .70$	=	$+\ .23$
32 *Eridani*	95 *Leonis*		$+\ .90$	$-\ .43$	$-\ .78$	$-\ .63$	=	$+\ .11$
ε Tauri	*ε Corvi*		$+\ .85$	$-\ .54$	$-\ .90$	$-\ .43$	=	$-\ .34$
μ Tauri	*o Virginis*		$+\ .84$	$-\ .55$	$-\ .92$	$-\ .39$	=	$+\ .33$
π⁵ Orionis	*δ Virginis*		$+\ .74$	$-\ .67$	-1.00	$-\ .10$	=	$-\ .41$
o Orionis	B.D. +2°2664		$+\ .65$	$-\ .75$	$-\ .99$	$+\ .14$	=	$-\ .33$
119 *Tauri*	*α Virginis*		$+\ .61$	$-\ .79$	$-\ .96$	$+\ .26$	=	$-\ .06$
θ Can. Maj.	*ε Bootis*		$+\ .40$	$-\ .92$	$-\ .73$	$+\ .68$	=	$-\ .13$
γ Geminorum	109 *Virginis*		$+\ .32$	$-\ .94$	$-\ .62$	$+\ .79$	=	$-\ .46$
19 *Monocerotis*	110 *Virginis*		$+\ .27$	$-\ .96$	$-\ .51$	$+\ .86$	=	$-\ .67$
23 *Hydrae*	*U Ophiuchi*		$-\ .31$	$-\ .95$	$+\ .59$	$+\ .81$	=	$-\ .11$
ι Hydrae	Ll. 32200		$-\ .40$	$-\ .91$	$+\ .73$	$+\ .68$	=	$-\ .69$
p² Leonis	*g Aquilae*		$-\ .56$	$-\ .83$	$+\ .93$	$+\ .37$	=	$+\ .62$
v Leonis	*ι Aquilae*		$-\ .80$	$-\ .61$	$+\ .96$	$-\ .27$	=	$-\ .37$
B.D. +2°2664	16 *Aquarii*		$-\ .98$	$-\ .19$	$+\ .38$	$-\ .93$	=	$-\ .46$
q Virginis	*ζ Aquarii*		-1.00	$+\ .10$	$-\ .20$	$-\ .98$	=	$+\ .27$
μ Virginis	*ζ Pegasi*		$-\ .99$	$+\ .15$	$-\ .29$	$-\ .95$	=	$+\ .16$
110 *Virginis*	*β Piscium*		$-\ .97$	$+\ .25$	$-\ .48$	$-\ .87$	=	$+\ .14$
3 *Serpentis*	*q Aquarii*		$-\ .95$	$+\ .29$	$-\ .56$	$-\ .83$	=	$-\ .36$
β Librae	*γ Piscium*		$-\ .95$	$+\ .31$	$-\ .60$	$-\ .80$	=	-1.02
37 *Librae*	70 *Pegasi*		$-\ .93$	$+\ .36$	$-\ .67$	$-\ .74$	=	$-\ .29$
ι Coronae	*A² Aquarii*		$-\ .86$	$+\ .51$	$-\ .88$	$-\ .48$	=	$-\ .44$
δ Ophiuchi	*ι Ceti*		$-\ .85$	$+\ .53$	$-\ .90$	$-\ .43$	=	$-\ .41$
B.A.C. 5647	17 *Ceti*		$-\ .76$	$+\ .65$	$-\ .99$	$-\ .15$	=	$+\ .27$
U Ophiuchi	*f Piscium*		$-\ .67$	$+\ .74$	-1.00	$+\ .10$	=	$-\ .36$
B.A.C. 5903	*μ Piscium*		$-\ .63$	$+\ .78$	$-\ .98$	$+\ .20$	=	$+\ .22$
Ll. 32200	B.D. −0°258		$-\ .60$	$+\ .81$	$-\ .95$	$+\ .29$	=	$+\ .98$
5 H Scuti	*γ Ceti*		$-\ .34$	$+\ .94$	$-\ .64$	$+\ .77$	=	$+\ .10$
g Aquilae	*α Ceti*		$-\ .27$	$+\ .96$	$-\ .52$	$+\ .85$	=	$+\ .06$
v Aquilae	*f Tauri*		$-\ .18$	$+\ .98$	$-\ .36$	$+\ .93$	=	$+\ .33$
ι Aquilae	10 *Tauri*	K	$-\ .12$	$+\ .99$	$-\ .25$	$+\ .97$	=	$-\ .34$

Giving to each equation unit weight, and forming normal equations in the customary manner, I derive from the latter the following

ELIMINATION EQUATIONS.

$$\begin{array}{rrrrrl}
38.00\,K - 1.67\,A & +\ 0.53\,B & -13.28\,C & -\ 4.88\,D & = & -1.''18 \\
21.37\,A & -\ 6.63\,B & -\ 0.13\,C & -\ 0.45\,D & = & +2.54 \\
 & 14.42\,B & -\ 1.73\,C & +\ 0.06\,D & = & +4.06 \\
 & & 14.50\,C & +\ 0.83\,D & = & +2.01 \\
 & & & 17.89\,D & = & -0.04
\end{array}$$

These equations furnish the values:

$$K = +0''.02 \quad \pm 0''.05$$

$$\begin{array}{llll}
A = +0.''21 & \pm 0.''06 \qquad & C = +0.''14 & \pm 0.''07 \\
B = +0.30 & \pm 0.07 & D = 0.00 & \pm 0.07
\end{array}$$

$$\text{and}\quad \Delta\alpha = \underset{\pm 0^s.003}{+0^s.014}\ \sin(\alpha + \underset{\pm 13^\circ}{145^\circ}) \ \underset{\pm 0^s.003}{+0^s.005}\ \sin(2\alpha + \underset{\pm 29^\circ}{90^\circ})$$

The value of $\Delta\alpha$ here given is the correction which must be applied to the right-ascensions of the *Berliner Jahrbuch*, in order to remove from the differences between computation and observation the systematic variations depending upon α which they present. By the introduction of these corrections the sum of the squares of the residuals is reduced from 7''.48 to 5''.63.

The excellence of the method here employed for determining the periodic errors of the right-ascensions is somewhat impaired in the present case by the small number of right-ascensions, 69 stars, involved, but despite this small number the results appear to me worthy of some considerable measure of confidence.

Madison, 1896 *April* 16.

THE SECULAR PERTURBATIONS OF *MERCURY* ARISING FROM THE ACTION OF THE *EARTH*,

BY ERIC DOOLITTLE.

The elements which have been used in the following computation are those given in Dr. G. W. HILL'S "*New Theory of Jupiter and Saturn*":

Mercury		*Earth*	
π =	75° 7' 13''.62	π' =	100° 21' 39''.73
i =	7 0 7.71	i' =	0 0 0.00
☊ =	46 33 8.63	☊' =	–
e =	0.20560476	e' =	0.01677114
n =	5381016''.26	n' =	1295977''.416
$\log a$ =	9.5878217	$\log a'$ =	0.0000000
m =	$\frac{1}{5000000}$	m' =	$\frac{1}{322800}$

Epoch 1850.0, Greenwich Mean Time.

The method employed is that which is fully developed in the first part of HILL'S memoir on "GAUSS' *Method of Computing Secular Perturbations*," (*Astronomical Papers prepared for the use of the American Ephemeris*, Vol. I, 1882). In this method, the formulas expressing the secular variations of any element involve, instead of an infinite series, a complex double integral which depends upon elliptic integrals of the first and second kinds. The first integration is rigorously effected; the second is approximated to by quadrature, the most convenient method being to make the integration with regard to the eccentric anomaly of the disturbed planet, the mean of a greater or less number of values being taken according as the orbit is more or less eccentric.

Tables for the computation of the first integral are given in HILL'S memoir. In an appendix to the work, he has suggested certain alterations which may be made in the formulas to advantage, but which require the computation of auxiliary tables differing from those which he has given. This method has been extended and tables computed by M. CALLANDREAU (*Annales de l' Observatoire de Paris*, Tome XVIII, 1885). It has not, however, been employed in the following computation.

Using the notation of HILL, there are first obtained the following constants:

$$\begin{array}{rl|rl}
I = & 7^\circ\ 0'\ 7''.71 & \log k = & 9.9978879 \\
\pi = & 208\ 34\ \ 4.99 & \log k' = & 9.9988719 \\
\pi' = & 233\ 48\ 31.10 & \log c = & 6.4491252 \\
K = & 334\ 57\ 50.59 & c = & 0.00028127 \\
K' = & 334\ 33\ 18.85 & &
\end{array}$$

The circumference of *Mercury's* orbit is then divided into twelve parts with respect to the eccentric anomaly and the values of the quantities employed in the computation determined for each point of division. The results are given in the following table:

E.	$\log r$	v	A	ϵ	$\log B$	$\log g$	h	l
°		° ' ''		° ' ''				
0	9.4878584	0 0 0.00	1.10386215	335 51 46.38	9.5081346	4.6886746	1.00008277	0.10349811
30	9 5026623	36 32 7.50	1.11164085	10 34 17.77	9.5220410	4.0203094	1.00111148	0.11024810
60	9.5407098	70 50 41.41	1.12870093	43 44 31.88	9.5522785	5.2331592	1.00173668	0.12668299
90	9.5878217	101 51 53.65	1.15278960	74 25 54.26	9.5905516	5.5977618	1.00128597	0.15122236
120	9.6303194	129 46 44.60	1.17861164	102 29 10.96	9.6257902	5.6799144	1.00022588	0.17810449
150	9.6589887	155 27 29.02	1.19808875	128 32 34.79	9.6486839	5.5330630	0.99978030	0.19802718
180	9.6690267	180 0 0.00	1.20368356	153 40 4.15	9.6539763	5.0510112	1.00066133	0.20274096

E.	log r	v	A	ϵ	log B	log g	h	l
		° ′ ″		° ′ ″				
210	9.658 9887	204 32 30.98	1.1927 3750	179 3 38.24	9.640 5643	2.159 6502	1.0021 6106	0.1902 9517
240	9.630 3194	230 13 15.40	1.1693 4301	205 53 6.21	9.611 3705	4.951 9684	1.0028 5589	0.1662 0585
270	9.587 8217	258 8 6.35	1.1420 8711	235 3 30.91	9.573 5272	5.423 5302	1.0021 2493	0.1396 8091
300	9.510 7098	289 9 18.59	1.1194 3230	266 54 2.60	9.537 5343	5.522 9224	1.0006 7710	0.1184 7394
330	9.502 6623	323 27 52.50	1.1062 8960	300 52 46.44	9.513 7154	5.343 7814	0.9997 7580	0.1062 3253
Σ_1			6.9036 3359	1108 32 42.18	7.489 0844		6.0062 3965	0.8957 0634
Σ_2			6.9036 3341	928 32 42.44	7.489 0831		6.0062 3954	0.8957 0625

E.	G	G'	G''	θ	log 𝔎	log 𝔏′	log 𝔑	log N	log P
				° ′ ″					
0	1.0000 7732	0.1035 5071	0.0000 4715	18 46 28.61	0.0358 6144	0.3205 3269	0.2294 7519	8.599 3188	8.919 7434
30	1.0011 1031	0.1102 5877	0.0000 0949	19 22 58.72	0.0382 8768	0.3237 2814	0.2330 5754	8.630 7049	8.953 4609
60	1.0017 1716	0.1268 3714	0.0001 3464	20 51 17.40	0.0445 1491	0.3319 1845	0.2422 3558	8.712 5510	9.042 8624
90	1.0012 3943	0.1515 2995	0.0002 6105	22 54 12.04	0.0540 8514	0.3441 7345	0.2562 9369	8.816 5734	9.159 7414
120	1.0001 6768	0.1784 3084	0.0002 6815	25 0 4.02	0.0648 7989	0.3585 8872	0.2720 8270	8.913 0565	9.271 2667
150	0.9997 3772	0.1982 4193	0.0001 7219	26 27 9.31	0.0730 3960	0.3692 2627	0.2839 7010	8.978 8974	9.348 2020
180	1.0006 4732	0.2028 1016	0.0000 5541	26 45 34.58	0.0748 3693	0.3715 6571	0.2865 8308	9.000 2544	9.371 2099
210	1.0021 6104	0.1902 9526	0.0000 0008	25 50 0.71	0.0694 9181	0.3646 0451	0.2788 0654	8.973 8846	9.336 6110
240	1.0028 4522	0.1662 7021	0.0000 5369	24 1 53.32	0.0597 3313	0.3518 6481	0.2645 6369	8.906 3079	9.255 6584
270	1.0020 9425	0.1399 0074	0.0001 8915	21 57 13.77	0.0495 0056	0.3384 6383	0.2495 6627	8.811 4799	9.147 9627
300	1.0006 3933	0.1187 9216	0.0002 8015	20 10 34.78	0.0415 8092	0.3280 6159	0.2379 1429	8.710 2233	9.037 4863
330	0.9997 5109	0.1064 6458	0.0002 0734	19 3 48.08	0.0370 0237	0.3220 3558	0.2311 6016	8.630 1758	8.952 2476
Σ_1	6.0060 9403	0.8966 9152	0.0008 3949	135 35 52.71	0.3214 0725	2.0625 3200	1.5328 5453	2.841 7119	4.898 2271
Σ_2	6.0060 9384	0.8966 9123	0.0008 3930	135 35 52.63	0.3214 0716	2.0625 3178	1.5328 5430	2.841 7160	4.898 2316

E.	log Q	log V	log J_1	log J_2	log J_3	log F_2	log F_3	log R_0	log S_0
0	8.828 7400	8.828 7147	9.998 4199	*n*7.924 8767	*n*8.658 4751	7.341 0249	*n*6.273 9576	8.310 3698	*n*6.585 1432
30	8.863 2763	8.863 2712	9.994 5389	*n*7.664 1375	*n*8.953 0512	*n*7.006 8423	5.635 2232	8.328 4601	*n*6.631 5383
60	8.953 9831	8.953 9113	9.993 6098	7.816 4574	*n*9.027 5633	*n*7.613 2672	*n*5.869 0782	8.408 5965	6.134 5310
90	9.072 2159	9.072 0772	9.996 2367	8.134 3346	*n*8.961 1088	*n*7.795 5685	*n*6.696 7951	8.526 2113	6.848 9552
120	9.184 9500	9.184 8079	9.999 1149	8.078 6500	*n*8.685 2483	*n*7.836 6448	*n*6.936 6401	8.639 0494	6.742 0791
150	9.262 9066	9.262 8156	9.999 9208	7.677 0206	8.037 0932	*n*7.763 2191	*n*6.922 5909	8.712 2017	*n*6.625 1568
180	9.286 5324	9.286 5032	9.998 4236	*n*7.468 8625	8.849 2129	*n*7.522 1932	*n*6.636 2942	8.727 7934	*n*7.130 8758
210	9.251 7535	9.251 7534	9.995 7296	*n*7.849 2470	9.060 1605	*n*6.076 5127	*n*5.015 3120	8.687 1688	*n*7.109 8209
240	9.169 6145	9.169 5861	9.993 6465	*n*7.768 2904	9.119 3540	7.472 6718	5.893 1945	8.606 9999	*n*6.520 8036
270	9.060 0557	9.059 9551	9.993 9994	*n*7.031 9946	9.066 3186	7.708 4525	*n*6.256 2371	8.510 2440	6.774 4443
300	8.947 7383	8.947 5885	9.997 0699	7.211 9318	8.866 4186	7.758 1488	*n*6.669 4900	8.418 1476	6.885 9444
330	8.861 3541	8.861 2431	9.999 8439	*n*7.420 0272	8.152 6751	7.668 5783	*n*6.668 4843	8.346 6103	6.355 1807
Σ_1	4.371 5583	4.371 1117	9.980 2846					5.110 9566†	−0.000 6106 280*
Σ_2	4.371 5621	4.371 1156	9.980 2693					5.110 9562	−0.000 6099 566*

E.	log W_0	$R_0 \sin v$ $+S_0(\cos v+\cos E)$	$-R_0 \cos v$ $+S_0\left[\frac{r}{a}\sec^2\varphi+1\right]\sin v$	$W_0 \cos u$	$W_0 \sin u$	$-2\frac{r}{a}R_0$
0	*n*7.489 3949	−0.000 769 437	−0.020 434 774	−0.002 710 273	−0.001 475 729	−0.032 46657
30	*n*7.816 0652	+0.011 967 951	−0.017 591 057	−0.002 756 307	−0.005 938 896	−0.035 02118
60	*n*7.981 8445	+0.024 315 363	−0.008 157 573	+0.001 568 518	−0.009 461 439	−0.045 97425
90	*n*8.036 0681	+0.032 727 249	+0.008 319 102	+0.007 047 203	−0.008 270 793	−0.067 18020
120	*n*7.879 4092	+0.032 844 271	+0.028 781 472	+0.007 040 911	−0.002 795 215	−0.096 06764
150	7.257 2691	+0.022 159 505	+0.046 499 171	−0.001 803 831	−0.000 126 962	−0.121 45034
180	8.132 4713	+0.002 703 372	+0.053 431 012	−0.011 914 874	−0.006 487 582	−0.128 83338
210	8.311 8663	−0.017 924 683	+0.045 456 375	−0.012 308 941	−0.016 399 928	−0.114 64781
240	8.289 2545	−0.030 714 227	+0.026 434 445	−0.003 784 440	−0.019 093 573	−0.089 23343
270	8.125 4193	−0.031 808 132	+0.005 466 897	+0.003 836 684	−0.012 785 779	−0.064 75510
300	7.810 5994	−0.024 103 783	−0.010 000 896	+0.004 783 818	−0.004 349 396	−0.046 99652
330	6.995 9903	−0.012 845 686	−0.018 098 650	+0.000 981 246	−0.000 137 335	−0.036 51581
Σ_1	+0.019 245 092*	+0.004 275 559	+0.070 053 686	−0.005 016 340	−0.043 662 934	−0.439 57179
Σ_2	+0.019 240 128*	+0.004 276 204	+0.070 051 841	−0.005 003 946	−0.043 659 693	−0.439 57044

* The corresponding numbers have been added.

† Upon adding the corresponding numbers we obtain, 0.220 9691 333
0.220 9691 117

The work has been carried twice through at different times, and verification-formulas or different forms of the equations have been used when it was possible. It is therefore probable that no considerable errors remain in these results.

A rough check is also obtained by comparing the sum of the quantities corresponding to the 1st, 3d, 5th, etc., points of division with the sum of the remaining quantities. The result of the application of this test is shown, the sums being Σ_1 and Σ_2 respectively.

By forming the values of $\frac{1}{12}(\Sigma_1+\Sigma_2)$ for the last five columns respectively, we obtain the following differential coefficients:

log coeff.

$$\left[\frac{de}{dt}\right]_{00} = + \quad 3752''.83\, m' \qquad 3.5743594$$

$$\left[\frac{d\chi}{dt}\right]_{00} = +299037.7 \; m' \qquad 5.4757260$$

$$\left[\frac{di}{dt}\right]_{00} = - \quad 4591.37\, m' \qquad n3.6619424$$

$$\left[\frac{d\Omega}{dt}\right]_{00} = -328218.0 \; m' \qquad n5.5161623$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +296589.7 \; m' \qquad 5.4721565$$

$$\left[\frac{dL}{dt}\right]_{00} = -390282.2 \; m' \qquad n5.5913788$$

If we adopt the above value of m', viz.: $m' = \frac{1}{322800}$, we obtain, finally, the following values:

$$\left[\frac{de}{dt}\right]_{00} = +0''.0116259$$

$$\left[\frac{d\chi}{dt}\right]_{00} = +0.9263870$$

$$\left[\frac{di}{dt}\right]_{00} = -0.0142236$$

$$\left[\frac{d\Omega}{dt}\right]_{00} = -1.0167843$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +0.9188043$$

$$\left[\frac{dL}{dt}\right]_{00} = -1.2090529$$

LeVerrier, from slightly different elements has obtained five of these coefficients, deduced from the series expanded in powers of the eccentricities and mutual inclination of the planes of the orbits (*Annales de l'Observatoire de Paris, Memoires*, Tome V, pp. 6, 7, 21). Adopting LeVerrier's mass of *Mercury*, $\frac{1}{354936}$, the values of the coefficients from the two methods compare as follows:

	Method of Gauss	Method of LeVerrier
$\left[\frac{de}{dt}\right]_{00} =$	$+0''.010573$	$+0''.01062$
$\left[\frac{di}{dt}\right]_{00} =$	-0.012935	-0.013029
$\left[\frac{d\Omega}{dt}\right]_{00} =$	-0.924724	-0.92346
$\left[\frac{dL}{dt}\right]_{00} =$	-1.09959	-1.1002
$\left[\frac{d\pi}{dt}\right]_{00} =$	$+0.835616$	$+0.83606$

University of Chicago, 1896 *March* 30.

RESEARCHES ON THE ORBIT OF γ *CORONAE BOREALIS* = Σ1967,

By T. J. J. SEE.

This close double star was discovered by William Struve in 1826; its components are of the fourth and seventh magnitudes, and of yellow and bluish colors respectively, so that the pair is generally very difficult. Struve happened to discover the companion near the time of its maximum elongation, when the polar coordinates were $\theta = 111°.0$, $\rho = 0''.72$. Measures in 1828, 1831 and 1833 showed that both angles and distances were steadily decreasing, and in 1835 the star appeared single under the best seeing. The companion was not again recognized with certainty until 1842, although Struve, O. Struve and Mädler searched for it repeatedly during the intervening period, and occasionally suspected an elongation. But the discordance in the angles of the supposed elongations justify the belief that the phenomena observed were probably nothing more than diffraction fringes, or some other kind of spurious discs. Mädler's observation of 332°.3 and 0''.18 at the epoch 1841.50 may be genuine, although at this time the star must have been excessively close. The binary character of the pair was early recognized by Struve, who pointed out the particular interest attaching to the system on account of its high inclination. γ *Coronae Borealis* has since been measured by many of the best observers, and yet the stars are so unequal and so close that the errors of observation assume formidable proportions, and render a satisfactory determination of the elements very difficult. The great inclination of the orbit throws nearly all the position-angles into small regions of about 10° on either side, and while the retrograde motion ought to make the angles steadily decrease, we are sometimes confounded by an appearance of direct motion (as from 1859 to 1863) which proves the existence of sensible systematic errors, probably due to the placing of the micrometer-threads parallel to the edges of unequal images.

It is equally confusing to find that instead of a steady increase and decrease in the distance, nearly all of the distances are in the immediate neighborhood of 0″.4: such measures are of course misleading, as the companion cannot be standing still at a constant angle and distance. While therefore it is clear that the elements cannot lay claim to such accuracy as could be desired, it will yet appear that they are good, and even excellent for observations which are so badly vitiated by accidental and systematic errors.

It is obvious that in case of a system whose orbit plane lies nearly in the line of vision, the angles will be practically useless unless measured with the greatest accuracy; yet in this instance, even, when the pair is fairly wide, we frequently find the angles of individual observers differing by so much as 10°, and when the stars are close the uncertainty in angle will amount to at least twice this quantity. On account of such conspicuous errors in angle we have based the present orbit largely upon the distances.

Doberck and Celoria are the only astronomers who have previously attempted an orbit for this pair.

P	T	e	a	Ω	i	λ	Authority	Source
			″	°		°		
95.50	1843.7	0.387	0.75	111.0	83.0	239.0	Doberck, 1877	A.N. Bd. 88
95.5	1843.70	0.350	0.70	110.4	85.2	233.5	Doberck, 1877	A.N. 2123
85.276	1840.508	0.3483	0.631	113.47	81.67	250.7	Celoria, 1889	A.N. 2904

From an investigation of the best observations I find the following elements:

P = 73.0 years.
T = 1841.0
e = 0.482
a = 0″.7357
Ω = 110°.7
i = 82°.63
λ = 97°.95
n = −4°.9315

Apparent orbit:

Length of major axis = 1″.30
Length of minor axis = 0″.175
Angle of major axis = 111°.3
Angle of periastron = 329°.6
Distance of star from center = 0″.068

The accompanying table shows the agreement of the above elements with the mean places.

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
			″	″	°	″		
1826.75	111.0	114.5	0.72	0.70	− 3.5	+0.02	2	Struve
1828.98	110.7	113.5	0.54	0.69	− 2.8	−0.15	3	Struve
1831.68	109.3	111.2	0.4 ±	0.63	− 1.9	−0.23 ±	1	Struve
1833.34	105.8	110.0	0.4 ±	0.57	− 4.2	−0.17 ±	2	Struve
1835.16	simplex	107.4	–	0.44	–	–	3	Struve
1836.52	oblong?	105.5	–	0.37	–	–	4	Struve
1840.78	75	95.1	cuneif.	0.16	−20.1	–	4	O. Struve
1841.50	332.3	314.8	0.18	0.10	+17.5	+0.08	10–4	Mädler
1842.61	300.4	301.9	0.33	0.21	− 1.5	+0.12	6–3	Mädler
1843.30	292.5	298.6	0.41	0.28	− 6.1	+0.13	3	O. Struve
1844.37	286.2 ?	295.5	-	0.37	− 9.3	–	1	Mädler
1845.61	296.0	293.1	0.44	0.45	+ 2.9	−0.01	5	O. Struve
1847.36	293.8	290.8	0.40	0.54	+ 3.0	−0.14	16–14	O. Struve, Mädler, 11–9
1848.44	294.9	289.7	0.4	0.57	+ 5.2	−0.17	7	Mädler, 4; W. C. and G. P. Bond
1849.63	289.9	288.6	0.50	0.58	+ 1.3	−0.08	3	O. Struve
1850.69	289.9	287.7	0.53	0.59	+ 2.2	−0.06	3	Mädler
1851.50	287.6	287.0	0.48	0.60	+ 0.6	−0.12	4	O. Struve
1852.07	285.1	286.5	0.57 ±	0.60	− 1.4	−0.03	4	Dawes
1853.17	286.2	285.6	0.45	0.59	+ 0.6	−0.14	9–10	OΣ., 5; Jacob, 0–2; Mädler, 4–3
1854.40	284.3	284.4	0.69	0.58	− 0.1	+0.11	2	Dawes
1855.73	292.4	283.3	–	0.56	+ 9.1	–	1	Mädler
1856.62	283.8	282.4	0.57	0.54	+ 1.4	+0.03	6–9	O. Struve
1857.52	281.0	281.4	0.50	0.52	− 0.4	−0.02	1	Dawes
1858.97	284.7	279.8	0.46	0.48	+ 3.9	−0.02	5	O. Struve
1859.36	282.6	279.4	0.45	0.47	+ 3.2	−0.02	1	Dawes
1861.59	287.7	276.2	0.42	0.41	+11.5	+0.01	3	O. Struve
1862.73	260.0	274.0	cuneo	0.38	−14.0	–	4	Dembowski, 3, Mädler, 1
1863.64	290.5	272.3	0.41	0.35	+18.0	+0.06	3	O. Struve
1865.50	280	267.7	<0.5	0.30	+12.3	+0.20	1	Engelmann
1866.62	286.0	260.0	0.43	0.24	+26.0	+0.19	2	O. Struve
1868.02	260.2	257.9	0.36	0.22	+ 2.3	+0.14	2	O. Struve

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o-\theta_c$	$\rho_o-\rho_c$	n	Observers
	°	°	″	″	°	″		
1872.91	192.5	209.0	–	0.13	−16.5	–	2	Wilson and Seabroke
1874.56	166.9	184.8	–	0.14	−17.9	–	1	Leyton observations
1875.41	165.4	175.3	–	0.11	− 9.9	–	1	Leyton observations
1877.54	163.3	156.3	0.44	0.18	+ 7.0	+0.26	2	O. Struve
1878.60	150.7	147.0	0.56	0.22	+ 3.7	+0.34	2	O. Struve
1883.57	129.1	130.3	0.41	0.36	− 1.2	+0.05	5	Schiaparelli
1884.53	127.6	128.0	0.33	0.41	− 0.4	−0.08	9–13	Per., 3–1; Sch., 6; En. 0–6
1885.54	134.3	126.8	0.35	0.43	+ 7.5	−0.08	3	Schiaparelli
1886.51	129.1	125.3	0.38	0.46	+ 3.8	−0.08	6	Schiaparelli
1887.51	126.6	124.2	0.38	0.48	+ 2.4	−0.10	13	Schiaparelli
1888.55	124.3	123.0	0.40	0.52	+ 1.3	−0.12	16–15	Schiaparelli
1889.50	119.8	122.0	0.41	0.54	− 2.2	−0.13	5–4	Hodges, 1–0; Sch., 4
1890.68	124.1	121.1	0.51	0.57	+ 3.0	−0.06	1	Bigourdan
1891.52	121.7	120.2	0.45	0.59	+ 1.5	−0.14	10	See, 1; Sch. 4; Hall, 4; Bigourdan, 1
1892.55	122.0	119.4	0.60	0.62	+ 2.6	−0.02	12	H.C. Wilson, 1; Big. 1; Sch. 7; Com., 3
1893.50	118.4	118.7	0.58	0.64	− 0.3	−0.06	2–4	Bigourdan, 2; Sch., 0–2
1894.54	120.4	117.9	0.57	0.66	+ 2.5	−0.09	6	Sch., 2; Bar., 4
1895.42	116.0	117.3	0.69	0.67	− 1.3	+0.02	6–3	See, 3; Comstock, 3–0

The following is a short ephemeris:

t	θ_c	ρ_c
	°	″
1896.50	116.6	0.69
1897.50	116.0	0.69
1898.50	115.3	0.70
1899.50	115.3	0.70
1900.50	114.1	0.70

According to this orbit, previous investigators have materially overestimated the period. While the time of revolution must at present remain slightly uncertain, it does not seem at all probable that this element can surpass seventy-five years. It follows, therefore, that γ *Coronae Borealis* belongs to the class of unequal binaries with moderately short periods. The inclination and line of nodes here obtained will probably be nearly correct, while the eccentricity is not likely to be varied by so much as ±0.05.

Recent distances have been appreciably undermeasured by several observers; the separation of the components is now about 0″.68, and will not change sensibly for several years. The star needs further observation, and astronomers should continue to give it regular attention; but owing to the peculiar shape of the apparent orbit great care must be exercised to avoid systematic errors, if the measures are to be of much value in effecting a further improvement of the elements.

The University of Chicago, 1895 *Oct.* 24.

ON THE OCCULTATION OF THE STAR B.A.C. 1746,*

By JOHN N. STOCKWELL.

On the evening of April 17, as I was casually looking at the moon through the telescope, I noticed a bright star directly in front of it, and not more than one half of its semi-diameter distant from the moon's limb. It was evident that an occultation of the star was about to occur; and I at once decided to note the time at which it took place. The local mean time of its disappearance I found to be $8^h\ 7^m\ 52^s$, which is probably not more than one second in error.

I then examined the list of *occultations* in the *American Ephemeris*, for the purpose of finding what star it was; but was surprised to find that there was no occultation, visible in the northern hemisphere, due on that evening. The star β *Tauri* had already suffered an occultation and was about one-half of a degree to the westward of the moon; while the next almanac star, B.A.C. 1772, would occur some eighty minutes later, and be visible only in the southern hemisphere.

I therefore had some trouble, from the limited means at hand, in finding what star it was; but I finally discovered by means of the *Edinburgh Catalogue*, that it was the star numbered 885, and corresponded to the number 1746 of *British Association Catalogue*.

The apparent place of the star was found to be,

$$\alpha = 5^h\ 29^m\ 24^s.55 \quad \text{and} \quad \delta = +27°\ 55'\ 51''.7$$

The Greenwich mean time of disappearance of the star was April 17, $13^h\ 34^m\ 30^s$; and the *American Ephemeris* gives for the place of the moon at that instant,

$$\alpha = 5^h\ 31^m\ 9^s.36 \quad , \quad \delta = +28°\ 1'\ 30''.2.$$

The geocentric latitude of the place of observation being $\phi' = +41°\ 18'\ 21''.5$, and the logarithm of the distance from the center of the earth being 9.9993651, I find for the moon's apparent place

---

* This star is DM. 27°806, and Weisse's Bessel V, 790. In the former it is given as $7^M.1$ and Bessel estimated it as 8^M. — Ed.

$$\alpha = 82^\circ\ 3'\ 4''.1 \quad . \quad \delta = +27^\circ\ 36'\ 39''.5$$

From the data thus determined, I found the apparent distance between the centers of the moon and star was 928″.9; while the apparent semi-diameter of the moon was 925″.7. The computed place of the moon at that time therefore differed from its observed place by only 3″.2, and serves to show the great excellence which has been attained in the construction of the moon's ephemeris.

The magnitude of the star as given in the *Catalogue* is $6^{M}.5$; and I am unable to understand why it was omitted from the list of occultations in the *American Ephemeris*, since that work purports to give the occultations of all stars above the ninth magnitude.

Cleveland, 1896 *April* 20.

OBSERVATIONS OF COMET *b* 1896 (*SWIFT*),

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY ARTHUR J. ROY.

1896 Albany M.T.		*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
April 27	8 18 36	4	10	+0 31.51	+2 57.0	3 14 16.07	+46 10 5.2	9.763	0.774
29	8 14 17	6	10	+0 35.88	+1 21.4	3 5 25.49	+50 15 56.4	9.787	0.777
May 12	9 31 41	8	10	−0 54.92	+9 4.5	1 43 50.98	+66 22 24.6	9.342	0.916
	10 43 41	10	8	−1 1.51	−8 37.6	1 43 30.85	+66 24 26.1	*n*9.086	0.920
13	9 39 48	11	4	+0 5.99	−0 22.4	1 36 38.64	+67 2 0.5	9.125	0.918
15	9 18 52	12	8	−0 40.60	−0 51.0	1 22 18.05	+68 10 52.2	9.126	0.915

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
4	3 13 41.87	−0.31	+46 6 58.5	+9.7	DM. 45°742. From comparison with *5
5	3 12 28.52		+46 11 34.2		Deichmüller. Bonn A.G. Catal. 2765
6	3 4 50.08	−0.17	+50 14 25.7	+9.3	DM. 50°719. From comparison with *7
7	3 1 57.07		+50 10 53.2		Rogers, Cambridge A.G. Catal. 1391
8	1 44 47.57	−1.67	+66 13 18.3	+1.8	DM. 66°167. From comparison with *9
9	1 41 23.08		+66 16 0.5		Fearnley, Christiania A.G. Catal. 328
10	1 44 34.08	−1.72	+66 33 2.0	+1.7	Fearnley, Christiania A.G. Catal. 336
11	1 36 34.39	−1.74	+67 2 21.9	+1.0	Fearnley, Christiania A.G. Catal. 321
12	1 23 0.46	−1.81	+68 11 43.6	−0.4	Anon 10^{M}. From comparison with *13
13	1 26 38.83		+68 8 51.5		Fearnley, Christiania A.G. Catal. 292

$\Delta\alpha$ measured micrometrically, except on May 12.

NEW ASTEROID.

Professor KREUTZ sends the positions of an asteroid found by Prof. WOLF upon his photographic plates at Heidelberg.

CT 12^{M} May 6 $10^{h}\ 45^{m}$ Heidelberg M.T., $\alpha = 14^{h}\ 36^{m}.7$, $\delta = -10^\circ\ 48'$
" 8 11 9.6 14 34.8 −10 34

The asteroid *CD*, found by WOLF 1895 Oct. 13, will be designated as no. 408.

Names have been assigned as follows:

No. 337, CHARLOIS, 1892 Sept. 22, *Derosa*. No. 338, CHARLOIS, 1892 Sept. 25, *Boudrosa*.
No. 340, WOLF, 1892 Sept. 25, *Eduarda*.

ON CERTAIN SYSTEMATIC ERRORS IN THE RIGHT-ASCENSIONS OF THE FUNDAMENTAL STARS, BY PROF. GEORGE C. COMSTOCK.
THE SECULAR PERTURBATIONS OF MERCURY ARISING FROM THE ACTION OF THE EARTH, BY MR. ERIC DOOLITTLE.
RESEARCHES ON THE ORBIT OF γ CORONAE BOREALIS = Σ1967, BY DR. T. J. J. SEE.
ON THE OCCULTATION OF THE STAR B.A.C. 1746, BY PROF. JOHN N. STOCKWELL.
OBSERVATIONS OF COMET *b* 1896 (SWIFT), BY MR. ARTHUR J. ROY.
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PUBLISHED IN BOSTON, TRI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed May* 30.

THE

ASTRONOMICAL JOURNAL.

No. 377.

VOL. XVI. BOSTON, 1896 JUNE 18. NO. 17

THE GENERAL PERTURBATIONS OF *NEMAUSA* OF THE FIRST ORDER BY *JUPITER*,

By A. HALL.

In the year 1864 I computed the special perturbations of *Nemausa* by the method of rectangular coordinates, from 1858 Feb. 13, to 1863 Oct. 25; formed five normal positions for the oppositions which had been observed, and corrected the elements by means of equations of condition. The results were published in the volume of the Naval Observatory for 1863, page LXXXIII. In the spring of the next year I began the computation of the general perturbations of this planet by HANSEN's method, but my work was interrupted by being ordered to the prime vertical instrument in September of that year, and soon afterwards to the meridian circle. The observations with these instruments, and especially the reductions, required so much time that my computations on *Nemausa* were laid aside, and nearly forgotten. A year ago I found and resumed my old work, and have finished the calculation of the first-order perturbations by *Jupiter*. The computation has been made anew from the beginning with my elements of *Nemausa*; but instead of BOUVARD's elements of *Jupiter* I have taken those of HILL. This change produced of course very little difference in the results, and the old calculations were essentially correct as far as they were made, that is to the β coefficients of HANSEN. The following are the adopted elements of the planets. The notation is that of HANSEN.

	Nemausa		*Jupiter*
	° ′ ″		° ′ ″
c =	1 57 16.7	c' =	38 8 15.7
π =	175 14 22.3	π' =	12 2 9.9
θ =	175 38 56.5	θ' =	99 0 49.1
i =	9 56 48.5	i' =	1 18 40.2
φ =	3 47 36.2	φ' =	2 45 56.9
$\log a$ =	0.3739513	$\log a'$ =	0.7162374
n =	975″.16863	n' =	299″.1283
m =	0	m' =	$\frac{1}{1047.8}$

These elements are for the mean equinox of 1858.0. The epoch for c, the mean anomaly, is 1858 March 25.5 Berlin M.T. The ratio of the mean motions, or

$$\mu = \frac{n'}{n} = 0.3067452$$

and the greatest factor of integration among the lower order terms comes from the form $1-3\mu$. The following table contains the coefficients of the perturbations of the coordinates chosen by HANSEN; which are the perturbation of the mean anomaly, $n\delta z$, the perturbation of the radius-vector, ν, and the perturbation of the coordinate perpendicular to the plane of the disturbed planet's orbit, or

$$\frac{u}{\cos i} = \frac{rs}{a\cos i}$$

The argument is $ie - i'A'$, where $A' = g' + \mu(e-g)$. g' is the mean anomaly of *Jupiter*, and e and g are the eccentric and mean anomalies of *Nemausa*.

Epoch = 1858 Mar. 25.5 Berlin M.T. ; $nz = 2° \; 2' \; 49''.8 + 975''.03561 + n\delta z$.

Argument	$n\delta z$		ν		$\frac{u}{\cos i}$	
	cos	sin	cos	sin	cos	sin
	″	″	″	″	″	″
0 0	. . .	. . .	− 0.23	. . .	− 0.61	. . .
0 0	. . .	. . .	+ 0.0128nt	. . .	− 0.2309nt	. . .
1 0	+456.42	+290.12	−143.57	+228.35	+ 7.94	+16.57
1 0	− 3.9586nt	− 0.3849nt	+ 0.1929nt	− 1.9793nt	+ 3.4897nt	+ 0.5037nt
2 0	− 7.74	− 4.20	− 0.53	− 0.15	+ 0.07	− 0.23
2 0	+ 0.0655nt	+ 0.0064nt	. . .	. . .	. . .	. . .
−2 −1	− 0.01	− 0.14	− 0.07	+ 0.01	+ 0.01	+ 0.06
−1 −1	− 0.02	+ 3.11	+ 2.06	+ 0.02	+ 0.04	− 2.14
0 −1	− 3.17	+ 25.03	+ 1.84	− 0.16	+ 0.65	− 4.48
1 −1	− 30.76	+103.53	− 38.08	− 11.33	+ 0.53	− 0.93

Argument	$n\delta z$		r		$\frac{u}{\cos i}$	
	cos	sin	cos	sin	cos	sin
	″	″	″	″	″	″
2 − 1	+ 0.50	− 0.94	− 0.38	+ 0.03	+ 0.88	− 1.91
3 − 1	+ 0.11	− 0.18	+ 0.15	+ 0.10	− 0.04	+ 0.07
−1 − 2	− 0.02	+ 0.22	+ 0.22	+ 0.03	+ 0.06	− 0.27
0 − 2	− 2.09	+ 6.96	+ 0.97	− 0.06	+ 1.31	− 3.50
1 − 2	− 64.60	+109.18	− 30.31	−18.44	− 3.58	+ 7.51
2 − 2	− 73.11	+109.37	− 67.72	−15.23	+ 0.45	− 0.49
3 − 2	+ 1.35	− 2.18	+ 0.03	− 0.06	− 0.29	+ 0.32
4 − 2	− 0.05	+ 0.05	− 0.04	− 0.05	+ 0.01	− 0.01
−1 − 3	+ 0.01	− 0.02	+ 0.03	+ 0.01	+ 0.01	− 0.04
0 − 3	− 1.96	+ 4.60	+ 1.38	+ 0.35	+ 1.91	− 3.71
1 − 3	−290.60	+399.40	− 28.60	−21.91	− 0.31	+ 1.01
2 − 3	−190.00	+221.30	−116.50	−99.80	−15.00	+16.55
3 − 3	+ 13.68	− 12.37	+ 6.38	+ 7.77	− 0.15	+ 0.11
4 − 3	− 0.16	+ 0.18	+ 0.02	+ 0.07	+ 0.10	− 0.06
5 − 3	+ 0.02	− 0.01	+ 0.01	+ 0.02	0.00	0.00
0 − 4	+ 0.12	− 0.22	− 0.11	− 0.06	− 0.17	+ 0.25
1 − 4	− 4.85	+ 5.37	+ 1.63	+ 1.62	− 0.58	+ 0.62
2 − 4	+ 32.95	− 29.55	+ 12.59	+14.17	+ 2.86	− 2.54
3 − 4	+ 7.82	− 4.88	+ 3.62	+ 5.58	+ 0.72	− 0.43
4 − 4	− 2.69	+ 1.16	− 0.86	− 2.07	+ 0.06	0.00
5 − 4	+ 0.02	− 0.02	0.00	− 0.04	− 0.04	+ 0.01
1 − 5	+ 0.02	+ 0.08	+ 0.12	+ 0.14	− 0.49	+ 0.15
2 − 5	+ 8.90	− 6.06	+ 1.79	+ 2.71	+ 0.46	− 0.32
3 − 5	+ 5.70	− 2.72	+ 1.73	+ 3.55	+ 0.78	− 0.36
4 − 5	− 2.06	+ 0.61	− 0.44	− 1.49	− 0.15	+ 0.04
5 − 5	+ 0.74	− 0.08	+ 0.06	+ 0.61	− 0.03	0.00
6 − 5	0.00	0.00	0.00	+ 0.02	+ 0.01	0.00
1 − 6	+ 0.10	− 0.02	+ 0.01	− 0.02	− 0.10	+ 0.07
2 − 6	+ 5.62	− 4.87	+ 0.58	+ 0.60	+ 0.06	− 0.02
3 − 6	+ 1.66	− 2.19	+ 1.21	+ 0.98	+ 0.96	− 0.30
4 − 6	− 1.09	+ 0.20	− 0.13	− 0.76	− 0.15	+ 0.02
5 − 6	+ 0.60	0.00	0.00	+ 0.48	+ 0.04	0.00
6 − 6	− 0.21	− 0.04	+ 0.04	− 0.18	+ 0.01	0.00
2 − 7	+ 1.51	− 0.56	− 0.08	− 0.24	+ 0.01	− 0.02
3 − 7	− 3.07	+ 0.58	− 0.26	− 1.40	− 0.35	+ 0.07
4 − 7	− 0.48	+ 0.01	− 0.01	− 0.36	− 0.10	0.00
5 − 7	+ 0.32	+ 0.04	− 0.03	+ 0.24	+ 0.04	+ 0.01
6 − 7	− 0.19	− 0.06	+ 0.05	− 0.16	− 0.01	− 0.01
7 − 7	+ 0.06	+ 0.03	− 0.03	+ 0.05	0.00	0.00
3 − 8	− 0.19	+ 0.01	0.00	− 0.01	. . .	. . .
4 − 8	− 0.29	− 0.03	+ 0.02	− 0.18	. . .	. . .
5 − 8	+ 0.14	+ 0.04	− 0.03	+ 0.10	. . .	. . .
6 − 8	− 0.10	− 0.04	+ 0.04	− 0.08	. . .	. . .
7 − 8	+ 0.06	+ 0.04	− 0.03	+ 0.05	. . .	. . .
8 − 8	− 0.02	− 0.02	+ 0.01	− 0.01	. . .	. . .
4 − 9	+ 0.04	+ 0.01	0.00	+ 0.01	. . .	. . .
5 − 9	+ 0.06	+ 0.02	− 0.01	+ 0.04	. . .	. . .
6 − 9	− 0.04	− 0.02	+ 0.02	− 0.03	. . .	. . .
7 − 9	+ 0.03	+ 0.03	− 0.02	+ 0.03	. . .	. . .
8 − 9	− 0.02	− 0.02	+ 0.02	+ 0.01	. . .	. . .

When the perturbations have been computed from osculating elements, as in the present case, the sum of the perturbations and their first differential coefficients for the epoch are put equal to zero for the determination of the six arbitrary constants. The constant denoted by k in HANSEN'S method enters with its full value into the correction of the adopted mean motion, and a small error in this constant will be multiplied by the time, so that the error in the mean anomaly may become important for a distant epoch. After the determination of the constants the elements, with the perturbations added, were compared with a position in 1892, and a small correction was found for the constant k. The result for the mean motion is placed at the head of the table of perturbations. The coefficients of the periodical perturbations were then corrected, when necessary, for the changes in the integrating factors.

In order to correct the adopted elements of the planet eight normals were formed, extending from 1858 to 1892, as follows:

Berlin M.T.	α	δ	C − O Δα	C − O Δδ
	° ′ ″	° ′ ″	″	″
1858 Mar. 16.75123	173 55 0.9	+2 19 47.8	+ 3.0	− 0.5
1860 Dec. 11.75123	77 5 24.9	+6 9 32.9	+44.6	+ 5.5
1863 Sept. 22.75123	0 50 28.7	−1 1 36.5	+14.1	+ 6.6
1867 Nov. 2.50000	43 30 0.2	+4 10 5.9	+49.6	+15.9
1871 Dec. 20.50000	89 0 11.3	+6 28 11.3	+ 1.3	+ 7.7
1876 Feb. 1.50000	144 49 47.8	+3 7 54.8	−10.7	− 4.9
1880 Apr. 15.50000	201 57 8.0	−0 11 36.3	+43.6	−33.6
1892 Sept. 8.50000	348 35 39.8	−2 23 44.3	+19.9	+23.7

The residuals given in the columns $\Delta\alpha$, $\Delta\delta$, result from the comparison of the elements and the perturbations with the normals. These computations were made with logarithms of six decimals, but as the planet was always near opposition the computed position should be accurate within a second of arc. A doubtful residual is that of the declination for 1880, but there appears to be no error in the computation. This declination, however, results from the difference of two nearly equal quantities. The elements of the planet were transferred to the equator, and equations of condition were computed for the geocentric right-ascension and declination. As the eccentricity is small the common device for avoiding the uncertainty arising from this source was used; that is, two auxiliaries, ϕ and ψ, were introduced,

$$\phi = \sin\varphi \sin\pi$$
$$\psi = \sin\varphi \cos\pi$$

In order to make the equations more convenient for solution the unit of the independent term was assumed to be 10″, and the correction to the mean motion was multiplied by 1000. The equations of condition with the logarithms of the quantities are as follows:

$$\begin{array}{rrrrrrrcl}
0.3063\,\Delta L & +n8.3791\,\Delta n & +\;0.5840\,\Delta\phi & +\;9.6212\,\Delta\psi & +\;9.3145\,\Delta\theta & +\;8.7740\,\Delta i & +\;9.4771 & = & 0\\
n9.6825 & 7.7885 & n9.9601 & n8.9779 & 0.2558 & 9.3979 & n8.6990 & = & 0\\
0.2191 & 0.2145 & n9.7267 & 0.5168 & n9.2344 & n9.0227 & 0.6493 & = & 0\\
8.9536 & 8.7819 & n9.3618 & 9.2165 & n9.6326 & 9.2064 & 9.7404 & = & 0\\
0.1513 & 0.4541 & n0.4743 & 8.5758 & 9.2934 & 8.2627 & 0.1492 & = & 0\\
9.5332 & 9.8348 & n9.8563 & n7.5674 & n9.9996 & n8.8809 & 9.8195 & = & 0\\
0.1744 & 0.7203 & n0.3380 & 0.3416 & 8.5567 & n9.2696 & 0.6955 & = & 0\\
9.4289 & 9.9660 & n9.6884 & 9.4871 & n0.1035 & 0.0097 & 0.2014 & = & 0\\
0.2353 & 0.9359 & 9.0359 & 0.5335 & n9.2989 & n8.4462 & 9.1139 & = & 0\\
8.1653 & 8.6448 & n9.3148 & 8.7224 & n9.0813 & 0.2239 & 9.8865 & = & 0\\
0.2863 & 1.1013 & 0.4736 & 0.3433 & 8.4987 & 9.3446 & n0.0294 & = & 0\\
n9.5492 & n0.3685 & n9.8109 & n9.4204 & 0.1109 & 0.0699 & n9.6902 & = & 0\\
0.3007 & 1.2067 & 0.5495 & n0.0731 & 9.2195 & n9.1509 & 0.6395 & = & 0\\
n9.6572 & n0.5610 & n9.9321 & 9.1920 & 0.2293 & n9.7932 & n0.5263 & = & 0\\
0.1528 & 1.2528 & n0.4660 & n9.8070 & 9.2366 & n8.9905 & 0.2989 & = & 0\\
9.5199 & +\;0.6203 & +n9.8371 & +n9.0886 & +n0.2066 & +n9.6226 & +\;0.3747 & = & 0
\end{array}$$

The normal equations are,

$$\begin{array}{rrrrrrrcl}
+24.659\,\Delta L & +115.744\,\Delta n & +\;8.702\,\Delta\phi & +16.605\,\Delta\psi & -\;2.590\,\Delta\theta & -0.455\,\Delta i & +\;30.322 & = & 0\\
 & +889.060 & +23.121 & +43.632 & -12.878 & -3.831 & +156.015 & = & 0\\
 & & +61.915 & -\;0.418 & -\;0.987 & +0.074 & -\;\;9.697 & = & 0\\
 & & & +34.382 & -\;1.822 & -0.058 & +\;17.317 & = & 0\\
 & & & & +13.396 & +0.096 & -\;12.679 & = & 0\\
 & & & & & +6.016 & +\;\;1.056 & = & 0
\end{array}$$

The solution gives

$$\begin{array}{rcl|rcl}
\Delta L & = & -14.''80 & \Delta\psi & = & +2.''475\\
\Delta n & = & +\;0.000004286 & \sin i\,\Delta\theta & = & +7.13\\
\Delta\phi & = & +\;3.764 & \Delta i & = & -2.98
\end{array}$$

The residuals remaining in the equations of condition are

Year	Δα	Δδ
	″	″
1858	−10.1	+15.1
1860	+25.4	+ 0.2
1863	−16.5	− 8.0
1867	+25.8	− 1.2
1871	−14.2	− 1.0
1876	−22.6	+ 3.2
1880	+26.7	−15.9
1892	−10.4	+ 5.9

These residuals should be multiplied by three-fifths to reduce them to heliocentric values. They are not much larger, I think, than one may expect for an interval of 34½ years, when the perturbations of *Saturn* are neglected, and those of the second order by *Jupiter*. Some of the normal positions are not very strong. Although this planet is generally of the 9th or 10th magnitude at opposition, yet the observations at the same observatory sometimes show discordances amounting to 5″ or 10″. The corrections found above are referred to the plane of the equator. Transferring them to the ecliptic, and applying them to the adopted values, we have the following elements of *Nemausa*:

$$\begin{aligned} L &= 177^\circ\ 11'\ 36''.1 \\ \varpi &= 175\ 13\ 21.3 \\ \theta &= 175\ 38\ 17.6 \\ i &= 9\ 56\ 52.3 \\ \varphi &= 3\ 47\ 34.0 \\ n &= 975''.035614 \\ \log n &= 0\ .3739907 \end{aligned} \quad \left.\begin{matrix} \\ \\ \\ \end{matrix}\right\} 1858.0$$

The next step would be to change the coefficients in the table of perturbations from the osculating elements of the planet to those depending on the mean elliptic elements. The principal result would be to reduce the terms depending on $\cos\epsilon$ and $\sin\epsilon$, or in this case, $+456''.42$ and $+290''.12$ in $n\delta z$; $-143''.57$ and $+228''.35$ in ν; $+7''.94$ and $+16''.57$ in $\frac{u}{\cos i}$, to very small quantities; while the other coefficients would undergo only slight changes. Hansen has given formulas for this change, *Auseinandersetzung*, Part 3, arts. 133–150; but the formulas as printed contain several errors, and ought to be revised before they are used.

As Hansen's method is undoubtedly the best we have for computing the perturbations of the minor planets, it may be interesting to give some of the statistics of my calculation of the perturbations of *Nemausa* by this method. This planet is situated near the inner part of the ring of asteroids, and there is not a very near approach to commensurability with the motion of *Jupiter*, so that for these reasons the coefficients are smaller than the average. I kept an account of the time spent in computing the perturbations, and found that the calculation required 385 hours, or 64 days, as computers' work in Washington. This time includes all that was spent in computing the checks, which Hansen has so carefully provided, and in correcting the errors. These checks are valuable, and in fact indispensable for one who is computing alone. I think that I am an average computer, and that by practice my time of computing the perturbations could be reduced to 300 hours. After the perturbations were computed it was necessary to form the arguments for each normal, look out the cosines and sines, and write down the products with the coefficients. There were 352 of these products for a normal, and the time required was about 4 hours. The computation, therefore, is laborious, and it is well to inquire if some process cannot be devised by which the principal part of the perturbations can be found with much less labor. The most promising method appears to be that of Dr. Bohlin, whose memoir was awarded a prize by the Academy of Sciences at Paris in December, 1894, but so far as I know this memoir has not been published.

1896 *April* 10.

NOTES ON VARIABLE STARS, — No. 13,

By HENRY M. PARKHURST.

The observations distinguished by a small capital P were made by Mr. Arthur C. Perry, of Brooklyn, N.Y., by Argelander's method, and have been reduced by myself to the photometric scale. His telescope has an aperture of 4 inches, with a magnifying power of 40 to 200. Some of these observations were made with the finder, aperture 1.3 inches, magnifying power, 8; and some with a field-glass, aperture 2.1 inches, magnifying power $5\frac{1}{2}$. The exact times of observation, state of the atmosphere, instrument used, &c., are recorded in his original notes, but are omitted here for typographic reasons. Most of the larger discrepancies between his observations and mine of the same date, have manifestly arisen from the use of different comparison-stars, some of them poorly determined. Difference of atmospheric conditions, even at the same approximate hour, must have affected our relative results.

Mira. In my early observations, *Mira* was near the horizon, and was compared only with distant stars. On several dates, indicated by a semicolon (Jan. 3, 4 and 13), the observations were taken during interruption from visible clouds, and that of Jan. 13 is rejected. On other evenings there were neighboring clouds, which may account for part of the apparent fluctuation. The coincidence of a slight depression noted by Mr. Perry, on Jan. 15, with my results, tends to show actual fluctuation in the star. The maxima given are the two principal smoothed crests, and are not affected by the rest of the light-curve. At the time corresponding to Max. *C*, of last year (*A.J.* 346), there were three stormy days. Observations for color were made upon a plan nearly identical with that of Chandler, (*A.J.* VIII: 137), the results of which are not yet fully reduced; but it seems probable that the redness of *Mira* has increased its photometric brightness.

(857). The light-curve has proved so fluctuating that I consider only the one maximum repeated from my former series available in determining the period. Apparently there is a disturbance at each third maximum; but cloudy weather has prevented my establishing it except on Nov. 28. These four maxima are rejected. The interpolation of the fraction of a day is uncertain, even in the cases where the two nearest dates were clear. From the seven remaining maxima, I deduce the elements $3213.52 + 17.39\,E$, with which the observed maxima are compared in the following table. A local correction of the standard, derived from comparison with other groups of $+0^{\mathrm{M}}.36$ has been applied. There has been no appreciable change in the average magnitude.

Comparison-Stars. In the lists of Comparison-Stars, there are groups repeated from my former catalogue, with later and better determined magnitudes. In such groups, wherever $n > 6$, the magnitude given is entirely independent of all observations prior to the date given, and n represents only new observations. Many comparisons have been made with surrounding groups to eliminate local errors of standard. The column n affords an indication which stars have been chiefly used in the comparisons, the relative magnitudes of which are best determined.

Results of Observations.

No.	Star	Phase	Observed Date		E	Corr.	W	Remarks
			Julian	Calendar				
				1895-6				
103	*T Andromedae*	Max.	3432.6	Aug. 26	55	+ 1	9	Yendell's elements, *A.J.* 335
“	“	Min.	3614 :	Feb. 24	56	–	1	$M - m < 100$, probably < 80
107	*T Cassiopeiae*	Max.	3414	Aug. 8	20	– 1	5	Assuming max. to be subsequent to Aug. 2
114	*S Ceti*	Max.	3496.0	Oct. 29	26	+11	9	A minor crest 17 days earlier
434	*S Piscium*	Max.	3503	Nov. 5	27	–46	5	Agrees with last year
466	*U Piscium*	Max.	3595	Feb. 5	34	0	5	An interval of 18 days
513	*R Piscium*	Max.	3596	Feb. 6	31	+ 3	9	Curve much flatter than last year
782	*R Arietis*	Max.	3474	Oct. 7	57	–13	7	Obsns. of Oct. 20 seems abnormal
806	o *Ceti*	Max.A	3563.8	Jan. 4	32	+27	9	See note above
“	“	Max.B	3575.2	Jan. 16	32	+38	9	Brighter than the highest last year
845	*R Ceti*	Max.	3550.8	Dec. 22	63	+ 2	9	Changes at max. rapid
(857)	– *Ceti*	Max.	3248.3	Feb. 23	2	0	6	1895; see note above
“	“	Max.	3457.0	Sept. 20	14	+.02	4	1896; four successive days
“	“	Max.	3474.5 :	Oct. 7	15	+.13	1	Descent only seen
“	“	Max.	3491.5	Oct. 24	16	–.26	5	4 obsns. on 3 successive days
“	“	Max.	3509.3	Nov. 11	17	+.15	5	Half weight for one obs. during clouds
“	“	Max.	3526 :	Nov. 28	18	:	5	Obsns. on Nov. 28 prove irregularity
“	“	Max.	3543.9	Dec. 15	19	–.03	5	Well determined regular maximum
“	“	Max.	3561.4	Jan. 2	20	+.08	3	Rejecting obsns. of Jan. 2
“	“	Max.	3578 :	Jan. 19	21	:	3	Interruptions; no regular max. shown
“	“	Max.	3595.8 :	Feb. 5	22	–.30	1	Estimated; clouds on nearest date
“	“	Max.	3613.5?	Feb. 23	23	+.01	2	Clouds on date of max.
“	“	Max.	3630.8 :	Mar. 11	24	–.08	1	Clouds for several days; uncertain
893	*U Ceti*	Max.	3527.1	Nov. 29	17	– 3	9	
906	*R Trianguli*	Max.	3502.0	Nov. 4	7	+27	9	Nearly corresponds with the second max. of last Jan.
“	“	Min.	3646	Mar. 27	8	+28	1	Mean of last two observations
1113	*U Arietis*	Max.	3501	Nov. 3	3	–48	5	Light-curve greatly changed
1222	*R Persei*	Min.	3541	Dec. 13	60	+ 1	3	
1386	*T Eridani*	Max.	3587	Jan. 28	–	–	5	Provisional period of 253 days suggested
1577	*R Tauri*	Max.	3604.4	Feb. 14	38	– 8	9	
1582	*S Tauri*	Max.	3590	Jan. 31	35	– 8	4	
1800	*W Orionis*	–	–	–	–	–	–	Changes very slow. See *A.J.* 366
1803	*T Leporis*	Max.	3511	Nov. 13	–	–	4	Including Paul's obsns. in *A.J.* 358
1805	*V Orionis*	Min.	3522 :	Nov. 24	7	–	0	Elements *A.J.* 347 and 350
“	“	Max.	3656	Apr. 6	7	+16	5	A very nearly equal crest 16 days earlier
–	DM. +3°764	–	–	–	–	–	–	See *A.J.* 367. No variation yet shown
1944	*S Orionis*	Max.	3597.4	Feb. 7	23	+26	9	Correction slowly increasing
2100	*U Orionis*	Max.	3631.8	Mar. 12	10	+ 4	9	Obsns. for redness not yet reduced
2445	*W Monocerotis*	–	–	–	–	–	–	Nothing satisfactory yet
2478	*R Lyncis*	Min.	3619 :	Feb. 29	21	–	–	At least three weeks earlier
2780	*T Geminorum*	Max.	3636	Mar. 17	60	–19	8	
2946	*R Cancri*	Max.	3525	Nov. 27	44	0	1	Probably earlier; inconsistent with last year.

Individual Observations.

103 *T Andromedae.*
(Continued from 346.)

Julian	Calendar	Mag.
d	1895	
3408.6	Aug. 2	9.91_2
3421.6	15	9.31_2
3424.6	18	9.07_2
3428.6	22	8.85_2
3431.6	25	8.76_2

103 *T Androm.*—Cont.

Julian	Calendar	Mag.
d	1895	
3434.6	28	8.84_2
3441.6	Sept. 4	9.05_2
3442.6	5	8.94_2
3447.6	10	9.04_2
3481.6	Oct. 14	9.32_2

103 *T Androm.*—Cont.

Julian	Calendar	Mag.
d	1895-6	
3510.5	Nov. 12	10.52_2
3539.6	Dec. 11	11.44
3544.5	16	11.50_2
3561.5	Jan. 2	12.45_2
3571.5	12	12.6]

103 *T Androm.*—Cont.

Julian	Calendar	Mag.
d	1896	
3574.5	15	12.9
3592.5	Feb. 2	12.9
3602.5	12	12.9
3606.5	16	13.1]
3622.5	Mar. 3	12.8]

107 *T Cassiopeiae.*
(Continued from 346.)

Julian	Calendar	Mag.
d	1895	
3408.6	Aug. 2	8.11_2
3421.6	15	8.12_2
3431.6	25	8.36_2

114 *S Ceti.*

(Continued from 314.)

Julian	Calendar 1895		Mag.
3448.6	Sept.	11	9.85
3460.6		23	9.32_2
3468.6	Oct.	1	8.44_2
3474.5		7	7.53_2
3481.6		14	7.66_2
3485.5		18	7.49_2
3487.5		20	7.60_2
3491.5		24	7.56_2
3495.6		28	7.45
3496.5		29	7.21_2
3499.5	Nov.	1	7.65_2
3501.5		3	7.75_2
3502.5		4	7.52_2
3513.6	Nov.	15	7.9P
3515.6		17	8.0P
3517.6		19	7.9P
3532.6	Dec.	4	8.7P

134 *S Piscium.*

(Continued from 346.)

Julian	Calendar 1895		Mag.
3454.6	Sept.	17	10.7]
3476.6	Oct.	10	10.82_2
3491.5		24	9.97_2
3515.5	Nov.	17	10.44_2
3542.6	Dec.	14	10.43_2
3550.5		22	10.67_2

466 *U Piscium.*

(Continued from 346.)

Julian	Calendar 1896		Mag.
3571.5	Jan.	12	11.3
3574.5		15	11.57_2
3592.5	Feb.	2	10.54_2
3602.5		12	10.79_2
3606.5		16	10.87_2

513 *R Piscium.*

(Continued from 346.)

Julian	Calendar 1896		Mag.
3570.5	Jan.	11	10.12_2
3571.6		12	10.3P
3573.6		14	9.9P
3574.5		15	9.6P
3575.5		16	9.57_2
3577.5		18	9.4P
3581.5		22	8.95_2
3586.5		27	8.85_2
3588.5		29	8.28_2
3592.5	Feb.	2	8.62_2
3600.6		10	8.61_2
3607.5		17	8.85_2
3612.5		22	8.61_2
3615.5		25	9.01_2

782 *R Arietis*

(Continued from 346.)

Julian	Calendar 1895		Mag.
3448.6	Sept.	11	9.77_2
3460.6		23	8.39_2
3468.6	Oct.	1	8.30_2
3477.6		10	8.38_2
3482.6		15	8.26_2
3485.6		18	8.50_2
3487.5		20	7.92_2
3495.6		28	8.85_2

806 *o Ceti.*

(Continued from 346.)

Julian	Calendar 1895-6		Mag.
3502.5	Nov.	4	9.2
3517.6		19	9.2
3528.5		30	8.56_2
3531.7	Dec.	3	7.8P
3540.7		12	7.6P
3542.5		14	8.50
3542.6		"	7.6P
3543.5		15	8.40
3544.6		16	7.9P
3550.5		22	7.30_2
3559.5		31	5.56_2
3560.4	Jan.	1	4.73_2
3561.4		2	4.70_2
3562.4		3	5.55_3:
3562.5		"	4.72_2
3563.4		4	3.31_3:
3563.5		"	4.52_3:
3564.4		5	3.82_2
3565.4		6	4.15_3
3565.5		"	4.62_2
3567.5		8	4.80_2
3568.6		9	4.39_2
3570.4		11	3.77_2
3570.5		"	4.0P
3571.5		12	3.68_2
"		"	4.1P
3571.6		"	4.47_2
3572.5		13	$(5.35_4:)$
3573.4		14	3.43_2
3573.5		"	3.4P
3574.4		15	3.71_2
3574.5		"	3.6P
3575.4		16	2.28_2
3575.5		"	3.22_2
3577.4		18	3.37_2
3577.5		"	3.3P
3581.4		22	3.23_2
3585.4		26	3.35_2
3586.4		27	3.12_2
3587.4		28	2.98_2
3587.5		"	3.76_4
3588.4		29	2.88_2
3588.5		"	3.36_2
3589.5		30	3.62_2
3592.4	Feb.	2	2.49_2
3596.4		6	3.58_2
3597.5		7	3.56_2
3600.5		10	3.96_2
3601.5		11	3.62_2
3602.5		12	3.26_2
3604.5		14	4.06_3
3606.5		16	3.78_4
3607.5		17	3.68_2
3608.5		18	3.91_2
3609.5		19	4.38_2
3611.5		21	3.15_2
3612.5		22	3.39_2
3614.5		24	3.31_3
3615.5		25	3.29_2
3617.5		27	4.07_2

806 *o Ceti.*—Cont.

Julian d	Calendar 1896		Mag.
3621.5	Mar.	2	3.89_2
3624.5		5	3.88_2
3627.5		8	3.75_2
"		"	4.1P
3632.5		13	4.94_2

845 *R Ceti.*

(Continued from 346.)

Julian	Calendar 1895-6		Mag.
3517.6	Nov.	19	11.8]
3540.6	Dec.	12	9.46_2
3542.5		14	9.54_2
3544.5		16	9.55_2
3546.5		18	9.37_2
3550.5		22	8.94_2
3559.5		31	9.29_2
3560.5	Jan.	1	9.47_2
3562.5		3	9.37_2
3563.5		4	9.15_2
3570.6		11	8.9P
3571.6		12	9.1P
3574.5		15	9.0P
3577.5		18	10.05
3577.6		"	9.6P

(857) *Ceti.*

(Continued from 346.)

Julian	Calendar 1895		Mag.
3448.6	Sept.	11	8.79_2
3450.6		13	8.69_3
3451.6		14	8.92_3
3452.6		15	8.84_3
3454.6		17	8.73_3
3455.6		18	8.70_3
3456.6		19	8.46_3
3457.6		20	8.59_3
3474.6	Oct.	7	8.60_3
3475.6		8	8.65_3
3476.6		9	8.72_3
3477.6		10	8.82_2
3481.6		14	9.23_2
3482.6		15	8.88_2
3488.6		21	8.79_2
3490.6		23	8.69_3
3491.51		24	8.34_3
3491.61		"	8.49_3
3492.64		25	8.96_3
3508.6	Nov.	10	8.88_3
3509.6		11	8.54_3
3510.5		12	9.04_4
3525.6		27	8.67_3
3526.5		28	8.88_3
3526.6		"	8.83_3
3527.5		29	8.86_3
3528.5		30	9.14_2
3533.6	Dec.	5	8.9P
3540.6		12	8.85_2
"		"	8.6P
3542.5		14	9.04_2
"		"	8.6P
3543.5		15	8.67_3
3544.4		16	8.68_3
3544.5		"	8.79_3
"		"	8.9P

(857) *Ceti.*—Cont.

Julian d	Calendar 1895-6		Mag.
3544.6	Dec.	16	8.94
3544.7		"	8.85_3
3545.6		17	9.12_2
3546.5		18	8.39:
"		"	9.2
3547.5		19	9.23_2
3550.5		22	8.50
3559.5		31	8.85_3
3560.5	Jan.	1	8.78_3
3561.5		2	8.61_4;
3562.5		3	8.54_2
3563.5		4	8.91
3570.5		11	8.6P
3571.6		12	8.6P
3574.5		15	8.6P
3575.5		16	8.83_2
3577.5		18	9.08_3
3577.6		"	8.6P
3579.6		20	9.34:
3581.5		22	9.71_2
3596.5	Feb.	6	8.62_3
3597.5		7	9.26_2
3611.5		21	8.70_3
3612.5		22	8.91_3
3614.5		24	8.95_3
3615.5		25	9.50_3
3624.5	Mar.	5	9.23_3
3626.5		7	9.19_3
3627.5		8	9.46_3
3628.5		9	9.18_3
3631.5		12	8.6 ;

893 *U Ceti.*

(Continued from 346.)

Julian	Calendar 1895		Mag.
3485.6	Oct.	18	10.0
3516.6	Nov.	18	7.91_2
3519.6		21	7.91_2
3519.7		"	7.3P
3525.6		27	7.60_2
3528.5		30	7.35_2
3532.5	Dec.	4	7.71_2
3533.6		5	8.09_2
3542.6		14	7.97_2
"		"	7.6P
3544.6		16	7.56_2
3545.6		17	7.82_2

906 *R Trianguli.*

(Continued from 346.)

Julian	Calendar 1895		Mag.
3427.6	Aug.	21	10.4
3442.6	Sept.	5	10.1
3448.6		11	9.70_2
3456.6		19	8.95_2
3468.5	Oct.	1	8.34_2
3477.5		10	7.42_2
3482.5		15	6.89_2
3485.6		18	6.43_2
3487.5		20	6.12_2
3491.6		24	5.78_2
3495.6		28	5.55_2
3496.5		29	6.05_2

906 *R Trianguli.*—Cont.

Julian	Calendar 1895-6		Mag.
3499.5	Nov.	1	5.66_2
3501.5		3	5.63_2
3502.4		4	5.44_2
3503.5		5	5.73_2
3510.6		12	6.21_2
3515.5		17	6.10_2
3525.6		27	6.22_2
3597.5	Feb.	7	9.8
3604.5		14	10.83_2
3612.5		22	11.03_2
3624.5	Mar.	5	11.04_2
3632.5		13	11.60_2
3640.5		21	12.00_2
3652.5	Apr.	2	11.99_2

1113 *U Arietis.*

(Continued from 346.)

Julian	Calendar 1895-6		Mag.
3460.6	Sept.	23	10.21_2
3469.6	Oct.	2	9.9
3485.6		18	9.67_2
3495.6		28	9.4
3517.6	Nov.	19	9.79_2
3525.6		27	9.52_2
3532.6	Dec.	4	9.68_2
3542.6		14	9.93_2
3559.5		31	10.26_2
3574.5	Jan.	15	10.88_2
3592.5	Feb.	2	10.8

1222 *R Persei.*

(Continued from 346.)

Julian	Calendar 1895-6		Mag.
3491.6	Oct.	24	11.4
3571.5	Jan.	12	12.2]
3575.5		16	12.2
3597.5	Feb.	7	11.1

1386 *T Eridani.*

Julian	Calendar 1896		Mag.
3564.5	Jan.	5	9.3
3575.6		16	7.59
3586.5		27	7.32_2
3588.5		29	7.07_2
3592.5	Feb.	2	7.69_2
3600.6		10	7.61_2
3612.5		22	8.31_2
3626.5	Mar.	7	8.88_2

1577 *R Tauri.*

(Continued from 350.)

Julian	Calendar 1896		Mag.
3571.5	Jan.	12	11.1
3573.6		14	11.1P
3574.6		15	11.07_2
"		"	11.3P
3577.5		18	11.10_2
3577.6		"	11.1P
3592.5	Feb.	2	10.26_2
3600.6		10	9.45_2
3604.5		14	9.28_2
3607.5		17	9.50_2
3612.5		22	9.84_2
3617.5		27	10.53_2
3624.5	Mar.	5	10.18_2

1582 *S Tauri.*

(Continued from 350.)

Julian	Calendar		Mag.
d	1896		
3571.5	Jan.	12	10.4
3571.7		"	10.3P
3573.6		14	10.3P
3574.6		15	9.89_2
"		"	10.3P
3577.5		18	10.04_2
3577.6		"	10.1P
3592.5	Feb.	2	10.36_2
3600.6		10	10.16_2
3604.5		14	10.12_2
3607.5		17	10.67_2
3624.5	Mar.	5	11.52_2

1800 *W Orionis.*

	1896		
3570.5	Jan.	11	6.4
3573.6		14	6.92_2
3585.6		26	6.91_2
3602.5	Feb.	12	6.75_2
3614.5		24	6.81_2
3624 5	Mar.	5	6.91_2
3624.6		"	6.3P
3627.5		8	6.5P
3632.6		13	6.5P
3633.6		14	6.5P
3636.6		17	6.4P
3643.5		24	6.55_2
3650.6		31	6.5P
3653.6	Apr.	3	6.3P

1800 *W Orionis.*—Cont.

Julian	Calendar		Mag.
d	1896		
3658.5	Apr.	8	6.36_2
3665.5		15	6.83_2

1803 *T Leporis.*

	1896		
3563.5	Jan.	4	9.0
3574.5		15	9.42_2
3600.6	Feb.	10	9.6
3601.6		11	9.96_2
3624.5	Mar.	5	10.52_2

1805 *V Orionis.*

(Continued from 350.)

	1896		
3570.5	Jan.	11	12.0]
3575.5		16	13.7
3597.5	Feb.	7	12.5
3624.5	Mar.	-5	11.5
3626.5		7	11.23_2
3632.5		13	11.00_2
3639.5		20	10.46_2
3640.5		21	10.35_2
3643.6		24	10.67_2
3646.5		27	10.62_2
3652.5	Apr.	2	10.51_2
3658.5		8	10.28_2
3665.5		15	10.70_2

DM. + 3°764.

	1894		
2854	Jan.	25	11.57
2857		28	11.56

DM. +3°764.—Cont.

Julian	Calendar		Mag.
d	1894		
2868	Feb.	8	11.13
2887		27	11.57
2904	Mar.	16	11.39
2915		27	11.52
	1896		
3570.5	Jan.	11	11.5 :
3597.5	Feb.	7	11.5 :
3624.5	Mar.	5	11.7
3626.5		7	11.54_2
3632.5		13	11.71
3639.5		20	11.57
3640.5		21	11.6
3643.6		24	11.7
3646.5		27	11.8
3652.5	Apr.	2	11.68_2
3658.5		8	11.56_2

1944 *S Orionis.*

(Continued from 350.)

	1896		
3570.5	Jan.	11	9.51_2
3577.5		18	9.26_2
3585.5		26	9.04_2
3588.6		29	8.33_2
3592.6	Feb.	2	8.26_2
3597.5		7	7.41_2
3602.5		12	7.56_2
3604.5		14	8.53_2
3607.6		17	7.79_2
3611.5		21	7.65_2
3612.6		22	8.17_2

2100 *U Orionis.*

(Continued from 350.)

Julian	Calendar		Mag.
d	1896		
3574.6	Jan.	15	9.6P
3577.7		18	9.8P
3592.5	Feb.	2	8.45_2
3602.6		12	7.84_2
3609.5		19	7.55_2
3614.5		24	7.11_2
3626.5	Mar.	7	6.81_2
3627.5		8	6.7P
3632.6		13	6.7P
3633.5		14	6.63_2
3633.6		"	6.5P
3636.6		17	6.5P
3639.5		20	6.78_2
3643.5		24	6.81_2
3643.6		"	6.8P
3646.5		27	6.84_2
3650.6		31	6.8P
3652.5	Apr.	2	7.26_2
3652.6		"	6.8P
3653.6		3	7.0P
3655.6		5	7.1P
3658.5		8	7.32_2
3658.6		"	6.9P
3665.6		15	7.2P

2445 *W Monocerotis.*

	1896		
3601.5	Feb.	11	10.9
3624.4	Mar.	5	10.3

2445 *Monoc.*—Cont.

Julian	Calendar		Mag.
d	1896		
3633.5	Mar.	14	10.9
3650.6		31	10.4
3652.6	Apr.	2	9.99_2
3658.5		8	10.10_2
3665.5		15	10.28_2

2478 *R Lyncis.*

(Continued from 350.)

	1896		
3577.5	Jan.	18	12.9]
3601.5	Feb.	11	12.9]
3624.5	Mar.	5	12.1

2780 *T Geminorum.*

(Continued from 308.)

	1896		
3601.5	Feb.	11	11.2
3609.5		19	9.81_2
3627.5	Mar.	8	9.09_2
3633.5		14	9.28_2
3639.6		20	9.05_2
3646.5		·27	9.36_2
3658.6	Apr.	8	9.69_2

2946 *R Cancri.*

(Continued from 350.)

	1895		
3525.6	Nov.	27	6.21_2
3526.6		28	6.36_2
3531.6	Dec.	3	6.95_2
3540.6		12	7.14_2

COMPARISON-STARS.

806 *o Ceti.*

1893–1896

Star	DM.	Mag.	*n*
E°	+3°419	2.18	29
1*J*°	+2°422	3.14	64
L°	+2°317	3.75	27
M°	−0°406	3.87	80
P°	+2°290	4.81	9
2*Q*°	−3°470	5.13	6
1*R*°	−4°502	4.93	7
1*T*°	−1°322	5.67	32
U°	−4°436	5.68	8
1*U*°	−0°355	5.84	9
C	−3°374	6.39	11

(857) — *Ceti.*

1893–1896

Star	DM.	Mag.	*n*
B	−0°378	6.48	6
K	+0°408	8.83	8
L	−0°367	8.61	167
1*L*	−0°374	8.59	124
1*R*	−0°373	9.56	100

1386 *T Eridani.*

Star	C.DM.	Mag.	*n*
P°	−24°1945	4.73	0*M*
D	−23°1619	6.22	3
E	−24°1981	6.81	4*M*
G	−25°1557	7.49	3*M*
H	−24°2001	7.90	6
I	−23°1642	8.43	3
M	−23°1641	8.99	6
P	−24°1996	9.53	6
2*P*	−25°1563	9.25	3*M*
S	−25°1594	9.20	0*M*
T	−24°2018	9.35	0*M*
U	−25°1664	10.00	0*M*

1800 *W Orionis.*

Star	DM.	Mag.	*n*
B	+0°923	5.98	2*M*
C	+1°886	6.58	3
1*C*	+0°975	6.12	6*M*
D	+0°988	6.47	6*M*
H	+0°974	6.63	6*M*
L	+0°946	7.14	3
1*L*	+0°957	7.29	3
R	+0°951	8.94	0*M*
1*R*	+0°959	8.62	2*M*
T	+0°933	8.89	0*M*
1*T*	+0°958	8.79	1
U	+0°915	9.14	0*M*

OBSERVATIONS OF COMET *b* 1896,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 12-INCH EQUATORIAL,

BY PROFESSOR EDGAR FRISBY.

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

1896 Washington M.T.	∗	No. Comp.	☄ − ∗		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
d h m s			m s	′ ″	h m s	° ′ ″		
April 29 8 11 56.5	1	15 , 3	+3 25.02	+ 3 53.0	3 5 21.61	+50 14 55.3	9.8135	0.7591
May 4 8 13 53.7	2	20 , 4	−3 31.44	+ 2 9.0	2 38 2.78	+58 26 2.9	9.8437	0.8102
8 18 2.6	3	20 , 4	+2 39.68	− 0 25.6	2 38 2.33	+58 26 23.4	9.8377	0.8158
6 9 3 34.2	4	20 , 4	+0 17.50	+ 2 50.4	2 25 13.44	+60 57 58.7	9.7349	0.8820
9 8 58 52.1	5	6 , 2	−1 2.54	−19 32.6	2 4 47.02	+64 2 34.0	9.3927	0.9264
14 11 19 20.5	6	19 , 4	+4 1.68	−11 36.3	1 28 51.75	+67 40 51.6	*n*9.6378	0.9060
15 11 18 57.7	7	20 , 4	+2 49.54	+ 6 3.0	1 21 37.82	+68 13 42.0	*n*9.6977	0.8983

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 4 57.07	−0.48	+50 40 53.2	+9.1	Rogers, Cambridge A.G. Catal. 1391
2	2 40 35.15	−0.93	+58 23 46.1	+7.5	Krueger, Helsingfors-Gotha A.G.Catal. 2515
3	2 35 23.61	−0.96	+58 26 41.8	+7.2	Krueger, Helsingfors-Gotha A.G.Catal. 2447
4	2 24 57.23	−1.29	+60 55 1.9	+6.4	Krueger, Helsingfors-Gotha A.G.Catal. 2303
5	2 5 51.08	−1.52	+64 22 0.5	+6.1	Krueger, Helsingfors-Gotha A.G.Catal. 1959
6	1 24 51.74	−1.67	+67 52 27.7	+0.2	Fearnley, Christiania A.G.Catal. 285
7	1 18 50.07	−1.79	+68 7 38.3	+0.7	Fearnley, Christiania A.G. Catal. 261

ORBIT AND EPHEMERIS OF COMET *b* 1896 (SWIFT),

By R. G. AITKEN.

The orbit and ephemeris of Comet *b* 1896 given below are based upon the following normal places:

G.M.T.	App. α	App. δ
	h m s	° ′ ″
April 18.5	3 37 4.59	+23 10 10.7
30.0	3 3 14.78	+51 7 42.6
May 25.5	0 11 12.87	+71 38 25.3

The times are corrected for aberration and the places for parallax.

The normal places were formed in the usual manner from the following observations:

I. Mt. Hamilton, HUSSEY, April 16, April 17 (2); AITKEN, April 19; Algiers, RAMBAUD and SY., April 18 (4), April 19 (2); Hamburg, SCHORR, April 19 (2); Kiel, LAMP, April 19.

II. Mt. Hamilton, HUSSEY, April 27, April 30, May 2; Hamburg, SCHORR, April 28 (2).

III Mt. Hamilton, AITKEN, May 23, 24 (2), 25, 26.

ELEMENTS.

$$T = \text{Greenwich M.T., April } 17.64665$$

$$\left.\begin{aligned} \Omega &= 178^\circ\ 15'\ 58''.1 \\ i &= 55\ 34\ 16.0 \\ \omega &= 1\ 44\ 7.6 \end{aligned}\right\}\ 1896.0$$

$$\log q = 9.753114$$

Residuals for the middle place, (O−C):

$$\Delta\lambda \cos\beta = -0''.4 \quad . \quad \Delta\beta = -0''.5.$$

Mt. Hamilton, 1896 *June* 1.

CONSTANTS FOR THE EQUATOR, 1896.0

$$x = r[9.999865] \sin(270^\circ\ 45'\ 17''.8 + v)$$
$$y = r[9.927969] \sin(179\ 51\ 28.1 + v)$$
$$z = r[9.725835] \sin(\ \ 3\ \ 1\ 57.7 + v)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1896	App. α	App. δ	log r	log Δ	Br.
	h m s	° ′			
June 12.5	22 10 50	+72 38.4	0.1072	0.0505	0.062
14.5	21 58 28	72 27.4			
16.5	21 46 24	72 13.4	0.1284	0.0637	0.053
18.5	21 34 42	71 55.5			
20.5	21 23 23	71 34.6	0.1485	0.0760	0.045
22.5	21 12 30	71 10.6			
24.5	21 2 5	70 43.4	0.1676	0.0875	0.039
26.5	20 52 10	70 13.1			
28.5	20 42 44	69 39.9	0.1857	0.0983	0.034
30.5	20 33 49	69 3.9			
July 2.5	20 25 26	68 25.1	0.2029	0.1088	0.030
4.5	20 17 33	67 43.7			
6.5	20 10 11	66 59.8	0.2194	0.1190	0.027
8.5	20 3 19	66 13.4			
10.5	19 56 56	65 24.9	0.2351	0.1290	0.024
12.5	19 51 3	64 34.2			
14.5	19 45 37	63 41.6	0.2501	0.1390	0.021
16.5	19 40 37	62 47.2			
18.5	19 36 3	+61 51.2	0.2645	0.1492	0.019

The brightness on April 13, the date of discovery, is taken as the unit.

CORRIGENDUM.

No. 376, p. 127, line 7 from below: *for* $\delta = +27^\circ\ 55'\ 51''.7$ *put* $\delta = +27^\circ\ 35'\ 51''.7$.

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CORRIGENDUM.

PUBLISHED IN BOSTON, TRI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed June 15.*

THE

ASTRONOMICAL JOURNAL.

No. 378.

VOL. XVI. BOSTON, 1896 JUNE 29. NO. 18

RESULTS OF RESEARCHES ON THE ORBITS OF FORTY BINARY STARS.*

By T. J. J. SEE.

Some three years ago I entered upon an examination of the present state of our knowledge respecting the orbits of double stars. The outcome of this investigation has been a new determination of all the orbits which can be defined with anything like a satisfactory degree of precision. A complete survey of the observations since the time of Sir WILLIAM HERSCHEL has enabled me to determine the orbits of forty stars. While the changes which future observations may require in the different orbits will of necessity be somewhat unequal, they will yet on the whole be small, and it is not probable that the corrections for any of the elements will introduce modifications of a radical character.

Among these forty stars we find that one was discovered by RICHAUD; one by BRADLEY; fourteen by Sir WILLIAM HERSCHEL; two by Sir JOHN HERSCHEL; five by WILLIAM STRUVE; eight by OTTO STRUVE; two by ALVAN CLARK; one by ALVAN G. CLARK; one by WINLOCK; and five by S. W. BURNHAM.

The great mass of observational material upon which our orbits rest is the outcome of the patient labor of a century. The problem before the early observers was to determine the relative positions of double stars, in order that when their motions should develop, astronomers of succeeding generations might use the accumulated observational material for investigating the nature of the orbits, and for studying the relations of the solar system to other systems in space. These important considerations lend to double-star astronomy a dignity which is not unworthy of the great names associated with its development. Besides the discoverers mentioned above, such observers as DAWES, MÄDLER, DEMBOWSKI, ENGELMANN, HALL and SCHIAPARELLI deserve the gratitude of mankind for their untiring devotion to the micrometrical measurement of double stars. The work of WILLIAM and OTTO STRUVE, DAWES, DEMBOWSKI, ENGELMANN, HALL, SCHIAPARELLI and BURNHAM is especially important to the computer, because the records extend continuously over many years, and give to the results a degree of homogeneity which is not found in the measures of the more sporadic observers. Yet even the smallest contribution of exact measures is a welcome addition to our knowledge, and sometimes proves to be of the highest importance in the determination of orbits.

The process which I have adopted in my researches is essentially a modification of the method of KLINKERFUES. The records of individual observers are grouped into suitable annual means, and use is made of both angles and distances. The points thus defined are regarded as approximate normal places which are subject to two conditions:

(1) That the areas swept over by the radius vector shall be proportional to the time; and

(2) That the orbit which satisfies the law of areas shall conform also to the observed distances.

In both cases reasonable allowance must be made for personal peculiarities of observers, and for the various accidental and systematic errors to which the measures are subject. These errors are in general so large compared to the quantities sought, that in the present state of double-star astronomy we seldom have occasion to apply corrections of a very minute character, and for this reason I have made no attempt to introduce refinements which are not warranted by the existing state of the observational material. In perhaps half a dozen cases definitive determinations might be undertaken with advantage, but it is doubtful whether it would be possible to effect a sensible improvement over the results obtained by the process of empirical adjustment here employed. In this work the observations were plotted on a convenient scale, and in each case an apparent ellipse was found which satisfied the distances and preserved the law of areas; fine planimeter measurement rendered the approximation to this apparent ellipse comparatively rapid, and the result was finally checked by deriving the elements and comparing the computed with the observed places. When the law of gravitation is assumed, and the apparent ellipse which satisfies the necessary conditions is taken as the projection of the real orbit described by the companion about the principal star in the focus, the elements are easily deduced by the method of KLINKERFUES. Proceeding in this manner we have obtained the elements of the forty double stars given in the accompanying table.

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* Read by invitation before the National Academy of Sciences, at the Washington meeting, 1896 *April* 22.

The approximate places of the stars are referred to the equator and mean equinox of 1900.0. On glancing over the major axes it will be seen that the most interesting and most rapid stars are so extremely close that their angular separation seldom surpasses one second of arc. As one-tenth of a second is the limit of exact measurement with our present optical means, it will be evident that although the errors of observation are small absolutely, they are yet very large in comparison with the whole distance to be measured. Under such conditions estimates by skilled observers are often as good as and sometimes better than measures determined by actual settings of the micrometer. It will readily be understood that in dealing with such material the theory of errors is of little use, and the exercise of judgement is above all things demanded of the computer.

RESULTS OF RESEARCHES ON THE

Star	α	δ	P	T	e	a″	☊	i	
	h m	° ′	yrs.			″	°	°	°
Σ3062	0 1	+57 53	104.61 ± 2.0	1836.26	0.450 ± 0.02	1.3712	47.15	43.85	90.9
η Cassiopeae = Σ60	0 42.9	+57 18	195.76 ± 10.0	1907.81	0.511 ± 0.03	8.2128	46.1	45.95	217.87
γ Androm. BC = *O*Σ38	1 57.8	+41 51	54.0 ± 1.0	1892.1	0.857 ± 0.02	0.3705	113.4	77.85	200.1
α Can. Maj. = Sirius	6 40.4	−16 31	52.20 ± 2.0	1893.50	0.620 ± 0.02	8.0316	54.3	46.77	131.03
F. 9 Argûs = β101	7 17.1	−13 38	22.0 ± 1.0	1892.30	0.700 ± 0.02	0.6519	95.5	77.72	75.28
ζ Cancri AB = Σ1196	8 6.2	+17 58	60.0 ± 0.5	1870.40	0.340 ± 0.03	0.8579	88.7	7.4	264.0
Σ3121	9 12.1	+29 0	34.0 ± 1.0	1878.30	0.330 ± 0.03	0.6692	28.25	75.0	127.52
ω Leonis = Σ1356	9 23.1	+ 9 30	116.20 ± 1.0	1842.10	0.537 ± 0.01	0.8824	146.70	63.47	124.22
φ Urs. Maj. = *O*Σ208	9 45.3	+54 33	97.0 ± 5.0	1884.0	0.410 ± 0.03	0.3140	160.3	30.5	15.9
ξ Urs. Maj. = Σ1523	11 12.9	+32 6	60.0 ± 0.1	1875.22	0.397 ± 0.005	2.5080	100.8	55.92	126.33
*O*Σ234	11 25.4	+41 50	77.0 ± 5.0	1880.10	0.302 ± 0.01	0.3467	157.5	50.8	206.8
*O*Σ235	11 26.7	+61 38	80.0 ± 5.0	1834.30	0.321 ± 0.05	0.8690	81.7	19.32	137.78
γ Centauri = H$_2$5370	12 36	−48 25	88.0 ± 3.0	1848.0	0.800 ± 0.03	1.0232	4.6	62.15	194.3
γ Virginis = Σ1670	12 36.6	− 0 54	194.0 ± 4.0	1836.53	0.897 ± 0.005	3.9890	50.4	31.0	270.0
F. 12 Com. Ber. = Σ1728	13 5.1	+18 4	25.56 ± 0.1	1885.69	0.461 ± 0.01	0.6416	11.9	90 ±	280.5
*O*Σ269	13 28.3	+35 16	48.8 ± 1.0	1882.80	0.361 ± 0.05	0.3248	16.2	71.3	32.63
25 Can. Ven. = Σ1768	13 33	+36 48	184.0 ± 25.0	1866.0	0.752 ± 0.05	1.1307	123.0	33.5	201.0
α Centauri	14 32.6	−60 25	81.10 ± 0.3	1875.70	0.528 ± 0.005	17.700	25.15	79.30	52.0
*O*Σ285	14 41.7	+42 48	76.67 ± 5.0	1882.53	0.470 ± 0.05	0.3975	62.2	41.95	162.23
ξ Bootis = Σ1888	14 46.8	+19 31	128.0 ± 1.0	1903.90	0.721 ± 0.02	5.5578	10.5	52.28	239.25
η Cor. Bor. = Σ1937	15 19.1	+30 39	41.60 ± 0.1	1892.50	0.267 ± 0.01	0.9165	27.1	58.5	217.57
μ^2 Boötis = Σ1938	15 20.7	+37 43	219.42 ± 10.0	1865.30	0.537 ± 0.03	1.2679	163.8	43.9	329.75
*O*Σ298	15 32.4	+40 9	52.0 ± 1.0	1883.0	0.581 ± 0.02	0.7989	1.9	60.9	26.1
γ Cor. Bor. = Σ1967	15 38.5	+26 36	73.0 ± 2.0	1841.0	0.482 ± 0.05	0.7357	110.7	82.63	97.95
ξ Scorpii AB = Σ1998	15 58.9	−11 5	104.0 ± 4.0	1864.60	0.131 ± 0.05	1.3612	9.5	70.3	111.6
σ Cor. Bor. = Σ2032	16 11	+34 7	370.0 ± 25.0	1821.80	0.540 ± 0.04	3.8187	30.5	47.48	47.7
ζ Herculis = Σ2084	16 37.6	+31 47	35.0 ± 0.3	1864.80	0.497 ± 0.03	1.4321	37.5	51.77	101.7
β416 = Lac. 7215	17 12.1	−34 52	33.0 ± 1.0	1891.85	0.512 ± 0.03	1.2212	144.6	37.35	86.1
Σ2173	17 25.3	− 0 59	46.0 ± 0.4	1869.50	0.200 ± 0.03	1.1428	153.7	80.75	322.2
μ^1 Herculis BC = A.C. 7	17 42.6	+27 47	45.0 ± 1.0	1879.80	0.219 ± 0.02	1.3900	61.4	64.28	180.0
τ Ophiuchi = Σ2262	17 57.6	− 8 11	230.0 ± 15.0	1815.0	0.592 ± 0.05	1.2495	76.4	57.6	18.05
F. 70 Ophiuchi = Σ2272	18 0.4	+ 2 33	88.3954 ± 1.0	1896.4661	0.500 ± 0.02	4.548	125.7	58.42	198.25
F. 99 Herculis = A.C. 15	18 3.2	+30 33	54.5 ± 3.0	1887.70	0.781 ± 0.02	1.014	indeter.	0.0	(*)
ζ Sagittarii	18 56.3	−30 1	18.85 ± 1.0	1878.80	0.279 ± 0.02	0.6860	69.3	67.32	328.1
γ Coronae Australis	18 59.6	−37 12	152.7 ± 5.0	1876.80	0.420 ± 0.02	2.453	72.3	34.0	180.2
β Delphini = β151	20 32.9	+14 15	27.66 ± 1.0	1883.05	0.373 ± 0.03	0.6724	3.9	61.35	164.93
F. 4 Aquarii = Σ2729	20 46.1	− 6 1	129.0 ± 5.0	1899.40	0.514 ± 0.03	0.7320	177.7	72.53	68.63
δ Equulei AB = *O*Σ535	21 9.6	+ 9 37	11.45 ± 0.2	1892.80	0.165 ± 0.02	0.452	22.2	79.0	0.00
κ Pegasi = β989	21 40.1	+25 11	11.42 ± 0.4	1896.03	0.490 ± 0.1	0.4216	116.25	81.2	89.2
F. 85 Pegasi = β733	23 56.9	+26 34	24.0 ± 1.0	1883.80	0.388 ± 0.02	0.8904	116.3	55.6	256.4

(*) Angle Per. = 169°.5.

I have indicated in the above table the probable uncertainty still attaching to the periods and the eccentricities, and it is easy to see from these possible variations about the extent to which the other elements may be altered. In some cases these estimated variations may prove to be too small, but care has been exercised to avoid over-estimation of the accuracy of results, and hence the values given above are not likely to prove very deceptive. Assuming that these variations are reasonably trustworthy, it is satisfactory to know that at length so many orbits have been found with such considerable precision.

The most striking characteristic of the orbits of double stars is their remarkable eccentricities. It appears from the results given above that the average eccentricity is 0.45, or about twelve times the mean value deduced from the orbits of the planets and satellites. If we divide the region of elliptic eccentricity from 0 to 1.0 into, say, ten parts, and ascertain the number of orbits falling in the several intervals, it will be found that none lie between 0 and 0.1; two between 0.1 and 0.2; four between 0.2 and 0.3; eight between 0.3 and 0.4; nine between 0.4 and 0.5; nine between 0.5 and 0.6; two between 0.6 and 0.7; four between 0.7 and 0.8; two between 0.8 and 0.9; none between 0.9 and 1.0.

ORBITS OF FORTY BINARY STARS.

n	Maj. Axis App.Orbit	Min.Axis App.Orbit	Angle of Maj.Axis	Angle of Periastr.	Star from Center	$\frac{\rho}{a}$	$\pm\frac{\kappa}{\rho}$	Magnitude	Light-ratio	Colors	Proper Motion	Γ	Γ′
°	″	″	°	°	″						″	°	°
+ 3.4414	2.526	1.984	45.7	138.4	0.446	0.572	0.261	6.9 ; 7.5	1 : 1.75	yellowish bluish white	0.267	67.4	59.3
+ 1.8390	15.81	10.24	55.8	254.5	3.80	1.320	0.716	4 ; 7	1 : 15.85	yellow purple	1.199	70.2	56.0
− 6.6667	0.706	0.084	109.9	289.0	0.298	0.611	0.232	5.5 ; 7	1 : 3.99	bluish bluish	. .	13.1	32.2
− 6.8966	14.63	9.50	50.7	252.4	4.16	1.161	0.715	1 ; 10	1 : 3981	white yellow	1.306	83.0	70.7
+16.3636	0.941	0.267	99.2	134.5	0.152	0.595	0.977	5.7 ; 6.3	1 : 1.74	yellow yellow	. .	54.0	68.3
− 6.0000	1.704	1.632	8.8	184.9	0.290	0.659	0.053	5.5 ; 6.2	1 : 1.91	yellow yellow	0.115	62.4	67.6
+10.5883	1.318	0.319	27.4	189.6	0.142	0.670	0.716	7.2 ; 7.5	1 : 1.32	white yellowish	0.523	81.1	56.2
+ 3.0981	1.576	0.738	141.1	293.4	0.317	0.460	0.387	6 ; 7	1 : 2.51	yellow yellow	0.040	13.4	65.7
+ 3.7114	0.690	0.530	167.6	174.1	0.149	1.015	0.032	5.5 ; 5.5	1 : 1	yellowish yellowish	0.028	26.4	64.2
− 6.0000	4.760	2.700	104.6	318.0	0.750	0.665	0.062	4 ; 5	1 : 2.51	yellow yellowish	0.736	59.4	57.5
+ 4.6754	0.695	0.437	158.0	355.2	0.098	0.924	0.399	7 ; 7.8	1 : 2.09	yellowish yellowish	0.115	42.1	64.6
+ 4.5000	1.682	1.020	72.8	231.1	0.242	0.912	0.577	6 ; 7.8	1 : 5.25	yellowish yellowish	0.129	89.4	19.3
− 4.0911	2.100	0.580	0.1	177.8	0.794	0.198	0.438	4 ; 4	1 : 1	yellowish yellowish	. .	83.3	74.0
− 1.8557	6.824	3.530	140.4	140.4	3.062	0.172	0.403	3 ; 3.2	1 : 1.20	yellow yellow	0.578	54.2	50.8
±14.0867	1.147	0.00	11.9	11.9	0.054	0.575	0.187	6 ; 6	1 : 1	orange orange	0.488	84.9	84.9
+ 7.3771	0.64	0.20	47.7	57.8	0.102	0.779	0.849	7.3 ; 7.7	1 : 1.45	yellowish yellowish	. .	69.3	60.5
− 1.9565	1.910	1.08	108.9	285.4	0.714	0.525	0.298	5 ; 8.5	1 : 25.12	white blue	0.114	19.8	47.3
+ 4.4390	32.18	6.16	27.25	38.65	5.90	0.670	0.982	1 ; 2	1 : 2.51	or. yellow or. yellow	3.685	47.8	88.1
− 4.6953	0.788	0.522	67.1	255.3	0.182	0.851	0.146	7.5 ; 7.6	1 : 1.10	yellowish whitish	. .	48.0	47.7
− 2.8125	9.07	5.76	167.7	144.7	2.94	1.100	0.790	4.5 ; 6.5	1 : 6.31	yellow purple	0.161	80.4	24.7
+ 8.6538	1.804	0.934	28.7	229.0	0.209	1.152	0.661	5.5 ; 6	1 : 1.59	yellowish yellowish	0.217	30.0	89.5
− 1.6407	2.656	1.480	173.5	186.7	0.638	0.912	0.419	6.5 ; 8	1 : 3.98	white white	0.194	11.5	77.5
+ 6.9231	1.546	0.656	186.9	15.3	0.427	0.582	0.695	7 ; 7.4	1 : 1.45	yellowish yellowish	0.500	25.5	83.1
− 4.9315	1.300	0.175	111.3	329.6	0.068	0.725	0.973	4 ; 7	1 : 15.85	yellow blue	0.115	78.0	89.6
+ 3.4616	2.696	0.884	9.6	150.2	0.085	0.935	0.639	5 ; 5.2	1 : 1.20	yellow yellow	0.098	29.5	71.0
+ 0.9730	7.08	4.71	42.4	66.9	1.735	0.750	0.631	6 ; 7	1 : 2.51	yellow bluish	0.342	18.5	88.7
−10.2843	2.498	1.752	43.1	289.0	0.455	1.180	0.559	3 ; 6	1 : 15.85	yellow bluish	0.613	86.4	21.2
− 9.0908	2.76	2.38	142.5	59.5	0.61	1.042	0.449	6.4 ; 7.8	1 : 3.63	yellowish yellowish	. .	71.9	86.0
− 7.8261	2.22	0.35	154.5	160.8	0.18	0.835	0.970	6 ; 6	1 : 1	yellow yellow	0.185	53.6	60.6
+ 8.000	2.78	1.148	61.4	241.4	0.304	0.822	0.698	9.4 ; 10	1 : 1.74	bluish white bluish	0.811	48.3	83.1
+ 1.5652	2.46	1.09	80.0	85.8	0.712	0.475	0.781	5 ; 6	1 : 2.51	yellowish yellowish	0.025	49.9	72.0
− 4.0728	9.00	4.17	122.9	295.8	2.198	1.475	0.848	4.5 ; 6.0	1 : 3.98	yellow purplish	1.123	76.7	88.9
+ 6.6055	2.028	1.278	169.5	169.5	0.792	. .	. .	6.0 ; 11.7	1 : 190.55	yellow purple	0.136	67.9	67.9
−19.098	1.300	0.423	74.8	82.8	0.168	1.223	0.430	3.9 ; 4.4	1 : 1.59	yellow yellow	. .	44.6	59.5
− 2.3575	4.906	3.661	72.2	252.1	1.033	1.045	0.180	5.5 ; 5.5	1 : 1	yellowish yellowish	. .	75.7	87.3
+13.015	1.060	0.477	2.5	176.6	0.194	0.645	0.828	4 ; 6	1 : 6.31	yellow yellowish	0.089	53.2	30.4
+ 2.7907	1.288	0.43	0.3	215.2	0.173	1.480	0.616	6 ; 7	1 : 2.51	yellow yellow	0.064	29.8	60.5
−31.441	0.904	0.171	22.2	22.2	0.075	0.930	0.532	4.5 ; 5.0	1 : 1.59	yellow yellow	0.300	20.1	39.4
−31.5236	0.555	0.130	115.7	30.2	0.032	1.390	0.503	4.3 ; 5.0	1 : 1.91	yellowish yellowish	. .	68.6	87.9
+15.0	1.52	1.00	118.0	18.2	0.197	0.610	0.062	6.0 ; 10	1 : 39.81	yellowish bluish	1.288	80.3	65.8

If now we represent these results graphically, using the x-axis as the axis of eccentricity and the y-axis as that of number of orbits, we shall find that the curve of distribution of orbits has a maximum near 0.45 in the region of mean elliptic eccentricity, and falls rapidly in either direction. It appears therefore that if we had an indefinite number of orbits the resulting illustration would become essentially a probability-curve with maximum near 0.45. Without touching upon the theoretical significance of this remarkable law of the eccentricity, we may add that although in any particular case the eccentricity of an orbit might depart from the mean here indicated as the most probable value, the prevailing tendency towards this mean region will on the whole prove useful to computers. Owing to the high eccentricities and the various inclinations of the orbits, it is not safe for observers to assume that the motion of stars whose orbits are unknown is anything like uniform in different parts of the apparent ellipses; for a shortening of the radius vector often takes place very suddenly, and as the areas are constant, this change will imply rapid angular motion. Several cases have occurred in which an arc of 180° has been swept over in a single year, and if observations could only be secured in this part of the orbit, where the motion is rapid, the definition of the elements would be greatly facilitated.

The foregoing table includes data defining the dimensions and positions of the apparent orbits, with the magnitudes, colors and light-ratios of the stars. As it seemed of interest to apply the theory of the relative motion of the components of a binary in the line of sight, developed in *Astronomische Nachrichten* 3314, we have moreover investigated the present orbital velocity of each star in units of the radius of the hodograph, and also determined what part of this motion is in the line of sight at the epoch 1896.50; the results of these computations are given in the columns marked $\frac{\rho}{a}$ and $\pm\frac{\kappa}{\rho}$, and may prove useful to workers in spectroscopic astronomy. It is to be remarked that η *Cassiopeae*, α *Canis Majoris*, F.9 *Argus*, ξ *Bootis*, γ *Coronae Borealis*, Σ2173, F.70 *Ophiuchi*, β *Delphini* and α *Centauri*, are favorably situated for spectroscopic measurement at this epoch. A single precise determination of the relative motion of the components will give us the parallax, mass, and dimensions of the system, and hence a line of investigation of such high interest will commend itself to the attention of spectroscopists who have great telescopes at their command.

If we inquire into the elements given in the above table with a view of ascertaining whether the planes of the stellar orbits have any decisive preference for the plane of the Milky Way, or any other plane inclined to this at a given angle, we shall find, as might be expected, that all possible inclinations exist, with no marked tendency to any given plane. Owing to our inability to distinguish between the ascending and descending node, there are two possible solutions of the problem of referring the orbit of a binary star to an absolute plane in space, but in many cases the spectroscope will eventually remove this uncertainty. Using the formulas of transformation developed by ENCKE (*Berliner Jahrbuch*, 1832) and adopting the coordinates for the North pole of the Milky Way given by Sir JOHN HERSCHEL ($\alpha = 12^h\ 17^m$; $\delta = +27°$), we get for the two possible inclinations to the galaxy the angles tabulated as Γ and Γ′. Now we do not know which of the two angles is the true inclination, but as it is not possible to select from the two columns any one prevailing angle, much less an inclination which is very small, we conclude that the planes of the stellar orbits are not in any way related to the Milky Way, or to any other absolute plane of the heavens.

It is also to be remarked, as might be expected from theory, that about half of the forty stars have direct, the other half retrograde motion. It is therefore impossible to deduce from the elements of the orbits any certain tendency save that of the eccentricity to a mean value, which is evidently a fundamental law of nature.

Observational verification of the universality of the law of gravitation is naturally suggested by the investigation of other systems in space. In dealing with the above forty orbits, we have encountered no outstanding phenomena which are not attributable either to errors of observation or to the disturbing influence of unseen bodies. There are several instances where the areal velocities do not appear to be perfectly uniform, but none sufficiently decisive to warrant us in attributing the deviation to the action of a dark body except in case of F.70 *Ophiuchi*. In every other case the irregularities, if real, are largely obscured by errors of observation, and more precise measures will be required before we can reach any certain conclusion.

There is thus every indication that the force is central, and presumably this force is gravitation, but as the Newtonian law can not be deduced from the phenomena of the apparent orbit, however accurately it may be determined, spectroscopic measurement alone offers the desired means of passing from the apparent to the real orbit, and of testing the theoretical position of the orbit-plane by comparing the computed with the observed motion in the line of sight. The method applies only to stars whose orbits are well determined, and the test that the principal star is in the focus of the real ellipse will be valid only to the extent of the precision of the observations. But if the results of theory could be substantially verified by observation in a single case, the achievement would be an interesting confirmation of the Newtonian law, which has been so ably discussed by Professors HALL, HALPHEN and DARBAUX.

The sensible constancy of the areal velocity in case of most of these stars enables us to say that the force is central, and the circumstance that the motion of F.42 *Comae Berenices* happens to lie in the line of vision, enables us to conclude that in one case, at least, the motion is sensibly in a plane. While there is therefore no serious doubt of the universality of the law of gravitation, the spectroscopic method is yet of great ultimate interest by virtue of the theoretical possibility of ascertaining generally whether the real orbit is a plane curve projected into the apparent ellipse. If this is confirmed, the law of gravitation can be established by showing that the companion moves about the principal star in the focus of the real ellipse. In the present state of spectroscopic measurement, this method of investigation would not be capable of great precision, but the verification of the Newtonian law is theoretically complete, and in practice the rigor of the experimental test would not be inferior to the accuracy of the observations of such distant phenomena.

Washington, D.C., 1896 *April* 21.

DOUBLE-STAR OBSERVATIONS.

By W. H. COLLINS.

The following results of double-star observations are a continuation of the Haverford College series. As hitherto the telescope used was the ten-inch Clark equatorial; the micrometer and magnifying power of 375 were the same.

The measures of angle were made with the line through the eyes perpendicular to or parallel with the line through the stars. Four measures of angle and two or more of double distance were made in every case.

The approximate positions are for 1900, and the magnitudes were only roughly estimated, part of them were made in bright moonlight, hence the discrepancies. The last two columns give the greatest differences between observed and mean angles and distances. The results are the mean of two or more nights' observation, with the exception of Σ 293 and 518 B : C.

Σ	α	δ	Year	θ_m	ρ_m	wt.	m	m	$\theta_o - \theta_m$	$\rho_o - \rho_m$
	h m	° ′		°	″				°	″
3062	0 1	+57 52	1895.862	332.0	1.64	4	6.5	7.0	0.3	0.10
3063	3	− 5 6	5.854	220.0	1.98	3	8.5	9.2	0.7	0.11
11	9	+77 28	5.862	193.3	8.22	3	8.0	10.5	0.7	0.24
13	10	+76 25	5.896	87.7	0.92	2	7.0	7.0	1.8	0.05
23	12	− 0 14	5.802	343.4	6.36	3	7.4	9.8	0.3	0.08
60	43	+57 17	5.862	206.0	5.99	2	. .	. .	0.4	0.02
67	47	+10 4	5.802	4.4	1.66	2	7.8	8.5	0.6	0.17
73	50	+23 5	5.934	13.4	1.46	2	. .	. .	0.3	0.17
91	1 2	− 2 16	4.882	321.9	3.86	2	7.0	8.0	2.0	0.14
110	13	−12 51	5.802	355.8	7.64	2	7.5	7.6	0.2	0.20
113	15	− 1 1	5.828	353.2	1.55	2	8.0	8.5	0.5	0.09
122	22	+ 3 3	5.802	330.3	6.08	2	6.8	9.0	0.3	0.03
133 A : B	27	+35 20	5.897	183.1	2.74	2	6.8	11.0	0.1	0.07
133 C : D	–	–	5.897	167.8	5.67	2	11.0	11.0	0.2	0.01
138	31	+ 7 7	5.850	36.8	1.68	2	7.5	7.5	1.1	0.01
147	37	−11 47	4.882	87.3	3.41	2	6.0	7.0	0.0	0.07
185	54	+75 2	5.862	25.6	1.40	2	7.0	8.8	1.7	0.15
202	58	+ 2 17	5.846	320.2	2.78	2	. .	. .	0.3	0.05
205	59	+41 51	5.876	63.2	10.48	3	. .	. .	0.9	0.30
231	2 8	− 2 51	5.407	232.2	15.98	2	5.0	7.0	0.4	0.28
249	15	+44 9	5.862	192.9	2.27	2	7.2	9.0	1.1	0.02
261	19	+11 2	5.898	68.8	2.84	4	9.0	9.0	0.4	0.22
293	36	+56 38	5.908	82.1	10.07	1	8.0	12.0	0.0	0.00
295	36	− 1 2	5.898	323.2	4.68	2	6.0	9.0	1.2	0.30
299	38	+ 2 49	5.407	291.3	2.90	2	. .	. .	1.5	0.07
305	42	+18 58	5.910	317.2	3.03	4	7.0	7.2	0.3	0.06
311	44	+17 3	5.912	120.1	3.14	3	. .	. .	0.3	0.30
312	47	+72 30	5.862	21.0	3.31	2	7.2	8.0	0.4	0.09
314	47	+52 34	5.862	301.1	1.71	3	7.0	7.0	0.7	0.02
333	54	+20 55	5.936	201.6	1.55	3	6.0	6.0	0.1	0.05
334	54	+ 6 15	5.898	317.0	1.43	4	8.2	8.4	1.0	0.11
367	3 9	+ 0 22	5.910	40.2	0.64	2	8.0	8.0	0.2	0.02
422	32	+ 0 16	5.897	247.1	6.19	3	6.2	8.8	0.1	0.15
460	53	+80 26	5.862	223.5	1.21	2	6.0	7.0	0.3	0.02
518 B : C	4 10	− 7 44	5.911	87.4	2.32	2	9.0	12.0	0.0	0.00
535	18	+11 8	5.920	331.2	1.69	3	7.2	8.2	1.0	0.07
566	32	+53 17	5.920	292.2	1.72	3	5.0	7.0	5.2	0.02
619	53	+50 7	6.067	121.2	5.06	3	9.0	9.0	0.4	0.01
622	53	+ 1 30	6.066	353.0	2.73	2	8.5	8.5	0.5	0.11
677	5 14	+63 18	5.920	251.3	1.46	4	7.0	8.2	1.1	0.06
694	18	+24 53	6.056	183.8	1.56	3	8.0	8.0	0.8	0.02
716	23	+25 4	6.056	199.8	4.99	3	6.0	6.0	0.3	0.04
727	26	+44 43	6.058	62.1	2.28	2	8.0	9.0	0.9	0.03
742	30	+21 57	6.056	258.8	3.44	3	7.0	7.0	1.4	0.15
749	32	+26 54	6.056	351.8	1.31	2	6.0	6.0	0.3	0.05
935	6 31	+52 23	5.927	327.3	5.10	2	7.0	8.0	0.1	0.14
948 AB	6 38	+59 33	1896.067	120.2	1.80	2	6.0	6.2	1.6	0.01

Σ	α	δ	Year	θ_m	ρ_m	wt.	m	m	$\theta_o-\theta_m$	$\rho_o-\rho_m$
	h m				″				°	″
918 AC	–	–	1896.067	305.1	8.22	3	6.0	7.5	0.5	0.27
1037	7 7	+27 26	6.052	307.0	1.01	2	8.0	8.0	0.2	0.07
1066	14	+22 9	6.080	205.3	6.89	2	. .	. .	0.2	0.25
1081	18	+21 39	6.080	226.2	1.18	2	. .	. .	0.9	0.16
1110	28	+32 6	5.348	226.6	5.80	3	. .	. .	0.2	0.18
1187	8 3	+32 31	6.096	45.2	2.20	3	7.5	8.0	1.4	0.05
1196 A : B	6	+17 58	6.082	17.4	1.25	2	6.5	6.7	0.7	0.10
1196 A : C	–	–	6.082	122.3	5.74	3	. .	7.0	0.4	0.05
1224	21	+24 51	6.082	42.8	5.96	3	6.0	7.0	0.2	0.07
1291	48	+30 58	6.096	326.0	1.49	2	6.0	6.0	1.2	0.15
1296	53	+35 21	6.096	75.3	2.26	2	9.0	9.5	1.3	0.08
1338	9 15	+38 37	5.384	162.4	2.02	2	. .	. .	0.8	0.22
1346	18	+54 27	5.352	311.0	5.60	2	. .	. .	1.5	0.10
1374	35	+39 25	5.384	283.8	3.32	2	7.0	8.5	0.8	0.04
1389	47	+27 27	5.385	311.6	2.31	2	8.8	9.2	0.5	0.06
1424	10 14	+20 21	5.339	293.2	3.74	2	. .	. .	1.4	0.11
1428	19	+53 8	5.352	86.2	3.44	2	. .	. .	1.0	0.01
1439	25	+21 29	5.385	117.8	2.05	2	. .	. .	1.3	0.10
1465	37	+45 9	5.394	10.8	2.40	2	9.5	9.3	0.4	0.01
1487	50	+25 17	5.385	105.4	6.46	3	6.0	7.0	0.8	0.16
1516	11 8	+74 0	5.384	97.2	17.47	2	7.0	7.5	0.4	0.05
1523	13	+32 6	5.411	173.2	2.36	3	. .	. .	0.3	0.07
1543	24	+39 53	5.411	359.0	5.50	3	6.0	8.5	0.9	0.03
1553	31	+56 41	5.390	166.0	5.82	3	7.5	9.3	2.1	0.02
1606	12 6	+40 27	5.390	333.0	1.40	2	7.5	7.5	2.1	0.14
1641	20	+38 17	5.420	33.7	10.71	2	10.2	10.2	0.4	0.42
1642	21	+45 17	5.401	181.0	2.82	2	7.5	9.0	0.2	0.01
1643	22	+27 35	5.454	41.9	1.91	2	9.0	9.2	1.5	0.09
1645	23	+45 21	5.420	160.0	10.15	3	7.0	7.8	0.5	0.11
1663	32	+21 45	5.454	98.0	0.96	2	8.6	9.2	0.8	0.10
1670	37	– 0 54	5.439	331.1	5.81	3	. .	. .	2.0	0.12
1676	40	+36 49	5.420	351.4	4.73	1	10.2	10.2	1.1	0.23
1687	48	+21 47	5.454	75.3	1.40	2	. .	8.2	0.3	0.23
1768	13 33	+36 48	5.454	138.4	1.38	2	. .	8.0	0.4	0.02
1785	45	+27 26	5.433	258.8	1.51	3	7.8	8.2	0.7	0.14
1808	14 6	+27 4	5.432	73.8	2.94	2	8.2	9.0	1.4	0.15
1810	7	+28 30	5.422	176.3	2.36	2	8.5	9.2	1.6	0.01
1813	8	+ 5 53	5.498	192.6	1.64	2	. .	. .	0.2	0.11
1817	9	+27 9	5.422	3.0	1.60	2	8.5	9.2	1.0	0.07
1820	10	+55 17	5.422	75.2	2.40	2	8.5	8.9	0.8	0.04
1825	12	+20 35	5.422	172.2	4.11	2	6.5	8.5	1.7	0.01
1830	13	+57 9	5.436	288.3	6.40	2	8.5	9.8	0.8	0.22
1831	13	+57 9	5.436	140.7	5.96	2	7.8	9.5	1.2	0.04
1842	22	+ 4 9	5.498	13.5	2.58	2	9.0	9.0	0.5	0.05
1863	35	+52 1	5.536	87.0	0.82	1	7.5	8.0	3.1	0.06
1864	36	+16 51	5.498	102.6	5.60	3	. .	. .	0.2	0.05
1871	39	+51 50	5.436	290.6	2.04	2	8.4	8.4	0.7	0.17
1877	41	+27 27	5.520	327.2	3.01	2	. .	. .	0.6	0.18
1888	47	+19 31	5.458	226.7	3.01	2	5.0	7.0	1.9	0.15
1909	15 1	+48 2	5.436	241.0	4.86	2	5.0	6.5	0.9	0.06
1926	11	+38 40	5.503	259.4	1.24	1	7.7	9.0	0.2	0.04
1932	14	+27 13	5.520	320.6	1.26	2	8.0	8.1	0.6	0.05
1934	14	+41 10	5.541	31.4	6.86	2	8.5	8.5	0.2	0.07
1954	30	+10 50	5.594	186.4	3.49	2	. .	. .	0.6	0.15
1956	30	+12 9	5.536	42.4	1.96	2	8.2	9.4	0.6	0.00
1957	31	+13 15	5.594	156.3	1.31	2	8.0	10.0	3.2	0.17
2021	16 9	+13 46	5.594	332.4	3.97	3	7.4	7.4	0.2	0.02
2023	10	+ 5 47	5.622	18.8	1.67	2	8.4	9.5	1.7	0.07
2032	12	+34 5	5.594	210.4	4.23	3	6.0	7.0	0.3	0.14
2044	16 21	+37 16	1895.594	341.2	8.35	3	7.7	7.7	0.8	0.06

Σ	α	δ	Year	θ_m	ρ_m	wt.	m	m	$\theta_o-\theta_m$	$\rho_o-\rho_m$
	h m	° ′		°	″				°	″
2054	16 23	+61 55	1895.685	6.6	1.66	2	6.6	8.4	4.5	0.69
2049	24	+26 12	5.622	208.6	1.22	3	7.2	7.8	0.4	0.04
2052	25	+18 36	5.618	95.5	2.47	3	6.8	7.5	1.3	0.14
2097	41	+35 55	5.622	84.3	2.06	4	7.8	8.2	0.6	0.10
2120	17 1	+28 13	5.622	243.4	6.99	3	7.0	9.0	0.2	0.23
2130	4	+54 36	5.622	152.4	2.44	4	5.2	5.4	0.8	0.10
2135	8	+21 21	5.594	176.8	7.32	2	. .	. .	0.3	0.05
2140	11	+14 30	5.622	114.7	4.48	4	. .	. .	1.0	0.01
3127	12	+24 57	5.622	189.2	15.38	4	. .	. .	0.9	0.05
2153	16	+49 25	5.592	270.4	1.93	2	9.0	9.5	0.1	0.06
2161	21	+37 15	5.592	310.8	3.68	3	. .	. .	0.3	0.08
2165	23	+29 33	5.592	53.6	8.07	3	8.5	10.0	0.4	0.11
2199	36	+55 48	5.622	91.8	1.54	4	7.5	8.0	0.1	0.14
2205	40	+17 46	5.626	126.4	2.36	4	8.8	8.8	0.7	0.11
2213	40	+31 11	5.592	330.4	1.56	3	8.0	9.0	0.4	0.09
2218	40	+63 42	5.592	345.2	2.16	3	7.0	8.5	1.4	0.08
2215	42	+17 45	5.766	294.0	0.95	2	. .	. .	1.6	0.15
2262	58	− 8 10	5.584	255.4	1.98	2	. .	. .	0.2	0.10
2267	59	+40 11	5.592	244.6	0.94	3	8.6	8.6	1.3	0.09
2271	59	+52 52	5.592	265.3	2.42	3	8.5	9.0	0.5	0.02
2272	18 1	+ 2 33	5.584	295.8	2.54	2	. .	. .	1.1	0.12
2289	6	+16 27	5.658	50.0	0.99	3	6.0	7.0	0.7	0.02
2292	8	+27 37	5.658	83.2	1.15	4	8.0	8.1	0.5	0.09
2303	15	− 8 2	5.710	224.0	2.64	2	7.0	9.5	0.1	0.06
2311	18	+11 22	5.714	159.8	6.08	2	8.8	10.2	0.0	0.26
2345	31	+21 0	5.710	203.3	8.80	3	8.5	10.0	0.3	0.18
2375	40	+ 5 24	5.568	112.0	2.38	2	7.0	7.0	1.1	0.16
2398	43	+59 26	5.630	149.4	17.28	3	8.0	9.0	0.2	0.12
2402	45	+10 33	5.636	205.3	0.92	3	8.0	8.0	0.1	0.04
2434 B : C	58	− 0 51	5.805	58.2	1.28	2	8.5	11.0	1.9	0.20
2437	58	+19 2	5.636	59.8	0.80	3	8.0	8.2	1.6	0.11
2455	19 3	+22 0	5.597	84.0	3.58	3	7.5	9.0	0.6	0.08
2457	3	+22 26	5.622	200.5	10.11	3	7.0	9.0	0.1	0.04
2471	6	+ 7 58	5.637	124.8	8.11	2	6.8	10.0	0.9	0.05
2479	6	+55 10	5.597	32.4	6.68	3	. .	. .	0.6	0.03
2481	8	+38 36	5.789	221.4	4.10	2	7.2	7.8	0.1	0.02
2482	9	+18 58	5.934	343.7	2.12	1	9.0	9.0	0.9	0.10
2484	10	+18 56	5.809	226.9	2.21	2	8.0	9.0	2.1	0.23
2488	11	+19 51	5.745	331.4	1.72	2	8.5	9.5	0.4	0.09
2524	22	+25 19	5.700	98.4	6.42	3	8.0	8.5	0.7	0.07
2527	23	+20 28	5.637	200.3	4.18	2	7.8	9.4	0.5	0.05
2530	24	+20 7	5.819	156.8	6.42	2	9.0	10.0	0.2	0.25
2541	31	−10 40	5.637	321.8	3.79	3	7.0	9.0	1.5	0.01
2544 A : B	32	+ 8 5	5.654	206.5	1.04	2	9.0	9.0	1.5	0.02
2576	42	+33 22	5.681	116.2	2.81	3	8.0	8.0	0.1	0.12
2579	42	+44 53	5.710	304.6	2.10	2	. .	. .	1.4	0.19
2583	44	+11 34	5.660	116.9	1.66	3	6.2	7.0	1.4	0.18
2603	48	+70 0	5.652	3.0	3.06	4	. .	. .	0.6	0.02
2596	49	+15 0	5.637	329.6	2.20	3	7.0	9.0	1.0	0.10
2607	54	+42 0	5.789	288.0	2.72	2	7.0	9.8	0.6	0.05
2624 A : B	59	+35 45	5.681	175.1	2.09	3	7.5	7.8	1.1	0.00
2640	20 4	+63 37	5.813	21.5	5.39	2	. .	. .	0.3	0.20
2658 A : C	11	+52 49	5.789	118.8	5.42	2	7.2	10.0	0.1	0.25
2725	42	+15 31	5.714	1.6	5.14	3	7.0	8.0	0.1	0.03
2726	42	+30 19	5.780	63.4	6.28	2	. .	. .	0.1	0.06
2737 A : B	54	+ 3 54	5.798	282.2	1.12	2	6.5	6.8	0.4	0.21
2741	55	+50 4	5.789	208.6	2.18	3	6.0	7.2	0.0	0.13
2744	58	+ 1 10	5.854	166.6	1.44	2	6.5	7.2	0.3	0.03
2746	58	+38 51	5.896	290.4	0.92	2	7.2	7.8	0.3	0.07
2749	21 0	+ 3 8	1895.714	157.8	3.72	2	7.2	9.6	1.9	0.06

Σ	α	δ	Year	θ_m	ρ_m	wt.	m	m	$\theta_o-\theta_m$	$\rho_o-\rho_m$
	h m				″				°	″
2758	21 2	+38 12	1895.771	123.6	21.66	4	. .	. .	0.2	0.04
2760	2	+33 12	5.771	46.5	7.08	3	7.2	8.0	0.1	0.03
2762	4	+29 49	5.771	131.0	3.60	2	6.0	8.0	0.1	0.18
2797	22	+13 46	5.714	215.8	3.28	3	6.8	8.2	1.2	0.26
2801	24	+79 55	5.818	273.8	1.70	3	7.0	8.0	0.1	0.04
2799	24	+10 40	5.711	123.0	1.59	3	7.0	7.0	0.2	0.13
2802	27	+33 22	5.774	9.4	4.01	3	7.8	7.8	0.8	0.04
2804	28	+20 18	5.771	331.4	2.96	4	7.8	8.0	0.2	0.05
2822	40	+28 19	5.771	121.2	2.92	4	4.5	7.0	0.8	0.06
2825	41	+ 0 26	5.741	113.8	1.05	3	8.0	8.5	0.3	0.01
2828 B : C	44	+ 2 54	5.775	218.6	3.84	2	8.6	9.0	1.1	0.48
2837	42	+82 29	5.843	296.5	2.77	2	8.0	8.5	1.7	0.33
2842	49	+63 34	5.874	102.1	3.63	2	8.0	11.5	1.3	0.01
2860	22 0	+60 22	5.812	257.4	6.94	2	7.5	9.0	0.4	0.05
2863	1	+64 13	5.835	283.0	6.92	2	5.0	7.0	0.6	0.03
2862	2	+ 0 11	5.741	281.4	5.95	3	7.8	8.2	0.5	0.13
2872 B : C	5	+58 48	5.853	137.6	0.71	3	8.2	8.4	1.8	0.05
2877	9	+16 48	5.836	359.9	11.88	3	6.0	8.0	0.1	0.30
2881	9	+29 2	5.784	99.6	1.90	3	7.8	8.5	1.7	0.01
2895	16	+24 26	5.774	33.4	7.50	4	8.0	9.8	0.3	0.05
2909	24	− 0 26	5.741	322.0	3.20	4	. .	. .	0.9	0.02
2910	24	+23 3	5.774	342.0	5.41	4	7.8	8.8	1.7	0.00
2913	25	− 8 36	5.718	330.1	8.34	3	6.5	7.5	0.5	0.08
2924	30	+69 23	5.871	269.7	0.82	3	7.0	7.0	2.7	0.10
2928	34	−13 18	5.785	314.9	4.30	2	7.5	7.5	0.7	0.15
2934	37	+20 56	5.854	149.5	0.98	3	8.0	9.0	1.1	0.09
2974	23 0	+32 50	5.781	162.0	2.75	3	8.0	8.0	0.1	0.03
3001	14	+67 33	5.835	193.9	2.76	3	5.0	7.5	0.6	0.13
3006	16	+34 52	5.884	166.8	5.54	2	8.2	9.0	0.4	0.14
3007	18	+20 0	5.774	81.5	6.17	3	6.2	9.0	0.7	0.01
3008	18	− 9 1	5.771	241.4	4.18	3	6.5	7.2	0.2	0.09
3037	41	+59 54	5.835	211.4	2.64	3	7.0	9.0	1.2	0.01
3038	41	+62 7	5.862	95.8	4.42	2	9.2	9.8	0.7	0.14
3046	51	−10 4	5.832	249.2	3.32	2	8.0	8.5	1.4	0.07
3050	23 54	+33 11	1895.884	210.7	2.76	3	6.5	6.5	0.1	0.10

Haverford College, Pa., 1896 *March* 27.

SUPPOSED NEW SOUTHERN VARIABLE,

BY ALEX. W. ROBERTS.

The star Cord. Zone-Catalogue XIV. 533 ($\alpha = 14^h\ 8^m\ 10^s$, $\delta = -57°\ 16'\ 12''$, eq. 1875.0) appears to vary within the limits $7^M.3$ and $7^M.7$. It has been observed irregularly for more than a year, but as yet I have been unable to secure a satisfactory period. I am however convinced of its variation within the period assigned; and the recorded observations seem to favor a period of about 22 hours.

1896 *April* 9

COMET *c* 1896 = COMET 1889 V.

A telegram from Kiel announces the rediscovery of this Comet by JAVELLE at Nice, on June 20. Its position was

June 20.5751 Gr. M.T. $\alpha = 22^h 25^m 37^s.8$ $\delta = -18° 33' 54''$.

thus showing the correction to Dr. POOR's ephemeris in *A.J.* no. 375 to be: $\Delta\alpha = -0^m\ 24^s.9$. $\Delta\delta = -2'\ 31''$.

Dr. POOR sends the following continuation of that ephemeris:

Gr. M.T.	App. α	App. δ	log. Δ	Br
1896	h m s	° ′ ″		
June 29.5	22 32 25.10	−18 15 57.6	0.16840	0.84
July 3.5	34 41.12	11 48.4		
7.5	36 33.50	9 22.8	0.13988	0.99
11.5	38 0.73	8 44.7		
15.5	39 2.21	9 45.2	0.11231	1.14
19.5	39 36.84	12 22.5		
23.5	39 44.72	16 22.0	0.08646	1.32
27.5	39 25.21	21 37.0		
31.5	22 38 39.27	−18 27 47.2	0.06318	1.52

CONTENTS.

RESULTS OF RESEARCHES ON THE ORBITS OF FORTY BINARY STARS, BY DR. T. J. J. SEE.
DOUBLE-STAR OBSERVATIONS, BY PROF. W. H. COLLINS.
SUPPOSED NEW SOUTHERN VARIABLE, BY PROF. ALEX. W. ROBERTS.
COMET *c* 1896 = COMET 1889 V.

PUBLISHED IN BOSTON, TRI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed June* 27.

THE

ASTRONOMICAL JOURNAL.

No. 379.

VOL. XVI. BOSTON, 1896 JULY 8. NO. 19

THIRD CATALOGUE OF VARIABLE STARS,

BY S. C. CHANDLER.

Since the appearance of the Second Catalogue, it has been the endeavor to keep pace with the rapid accumulation of new material by the occasional issue of Supplements. The time appears now to have arrived when a new edition of the catalogue is necessary, incorporating everything up to date. The elements of all the known variables have therefore been revised by means of all the published maxima and minima. This revision has extended also to the columns giving the maximum and minimum brightness, as well as to those giving the epochs and the periods with their inequalities. Where the comparison of the newer observations with the former elements indicated no appreciable certain correction, the elements of the Second Catalogue have been retained; although the data in the columns of "Basis of Elements" have been changed, in order to indicate, as well as can be done by so succinct a form of statement, the actual present condition of the observation of the various stars. This will enable observers to regulate their selection of the objects most needing observation.

These columns also illustrate how remarkable has been the degree of uniformity and completeness of the observation of the phenomena, and the consequent development of our knowledge with regard thereto, during the past few years. Very few stars, within reach of the astronomers of the northern hemisphere who have so actively devoted their energies to this class of work, have been seriously neglected. It is especially interesting to note the fact that this harmonious development has been attained without any concerted scheme of "cooperation," but by the free will and independently planned efforts of individual volunteers, each discriminatingly directing his work in accordance with his means and situation. Such a satisfactory result could hardly have been reached so effectively by a formal organization of work, directed from headquarters prescribing and circumscribing the operations of each participant, and destroying, by its benumbing influence, the enthusiasm which springs from the individual initiative of the observers themselves.

Tribute should be paid to the zeal and industry of all the astronomers who have contributed to the observation of the phenomena; but, as it might seem invidious to do so by naming even those most prominent in the work, it seems better to refer to the honorable records of all, which can be found especially in the annual indexes of the *Astron. Journal* and *Astr. Nachrichten.* This work of the accurate observation of the phenomena, which, as in the case of the comets, is of a much higher grade than the discovery of new objects — is the most essential element in the progress of this branch of astronomy, and is a field affording ample room for more participants. In the southern hemisphere, particularly, the need for volunteers is pressing.

The construction of the present catalogue is in every respect similar to that of the Second Catalogue (*A.J.* 300), and is fully described in its introduction, which it seems scarcely needful to repeat here. In nearly all points the nature of the contents of the several columns is self-evident from their headings, and for those in which this is not entirely so, a reference to the place mentioned is easy.

In the case of many of the more recently-discovered variables, while there are no definitely observed maxima available, sufficient data exist for making a guess at the probable period and an approximate epoch. These rude elements will serve as a useful guide to observers, and have therefore been inserted, but marked with a query to indicate that the times of maxima computed from them are precarious.

Where the elements depend on other authority than the writer's, the name is appended, in parentheses, in the column of remarks.

It is a source of regret that circumstances prevent the insertion, in the notes at the end of the Catalogue, of more copious descriptions relating to peculiarities of the various light-curves. But to attain any considerable degree of generality or completeness in this respect requires much more space than can be given in a publication in this form, and the labor of their proper preparation would also unduly delay its appearance.

No.	Star	1900.0 R.A.	1900.0 Decl.	1900 Annual Variation		1855.0 R.A.	1855.0 Decl.	Redness	Magnitude Max.	Magnitude Min.
		h m s	° ′	s	′	h m s	° ′			
22	V Sculptoris	0 3 39	−39 50.7	+3.05	+0.33	0 1 21	−40 5.8	–	8.9	<12.1
62	S Sculptoris	10 19	−32 36.1	3.04	0.33	8 2	−32 51.1	–	6.5	10.0
100	T Ceti	16 42	−20 36.7	3.04	0.33	14 26	−20 51.8	4	5.1– 5.3	6.4– 7.0
103	T Andromedae	17 10	+26 26.4	3.12	0.33	14 50	+26 11.4	–	7.7– 8.4	13?
107	T Cassiopeae	17 49	+55 14.3	3.22	0.33	15 25	+54 59.3	7.3	7.0– 8.0	11.0–12.0
110	S Tucanae	18 24	−62 14	2.87	0.33	16 14	−62 29	–	8.7	<11.6
112	R Andromedae	18 45	+38 1.4	3.16	0.33	16 25	+37 46.4	5.0	5.6– 8.6	<12.8
114	S Ceti	18 58	− 9 53.0	3.05	0.33	16 41	−10 7.9	2.0	7.0– 8.0	12
116	B Cassiopeae	19 15	+63 35.5	3.30	0.33	16 47	+63 20.6	–	>1	?
146	T Sculptoris	24 17	−38 27.7	2.96	0.33	22 3	−38 42.6	–	8.6	10.0
161	T Piscium	26 49	+14 2.9	3.11	0.33	24 29	+13 48.0	0	9.5–10.2	10.5–11.0
209	α Cassiopeae	34 50	+55 59.3	3.38	0.33	32 18	+55 44.5	5	2.2	2.8
224	S Andromedae	37 15	+40 43.2	3.26	0.33	34 49	+40 28.3	5	7	?
243	U Cassiopeae	40 46	+47 42.6	3.33	0.33	38 16	+47 27.8	6	8.0– 8.8	<15
294	W Cassiopeae	48 59	+58 0.9	3.53	0.32	46 21	+57 46.5	–	8.6	11.4
320	U Cephei	0 53 23	+81 20.2	5.09	0.33	0 49 38	+81 5.5	0	7.1	9.2
401	U Sculptoris	1 6 50	−30 38.8	2.85	0.32	1 4 42	−30 53.2	–	8.7	<12.5
419	U Andromedae	9 47	+40 11.2	3.41	0.32	7 14	+39 56.0	6	8.9 .	<13
432	S Cassiopeae	12 18	+72 5.1	4.35	0.32	9 4	+71 50.8	6.7	6.7– 8.6	<13.5
434	S Piscium	12 21	+ 8 24.3	3.13	0.32	10 0	+ 8 9.9	1.0	8.2– 9.3	<14.7
466	U Piscium	17 41	+12 20.7	3.17	0.32	15 18	+12 6.4	–	9.5–10.0	14.5–15.0
494	R Sculptoris	22 22	−33 3.5	2.77	0.31	20 17	−33 17.8	9	5.7– 7.5	7.6– 8.0
513	R Piscium	25 29	+ 2 21.9	3.09	0.31	23 10	+ 2 7.9	2.0	7– 8.8	<13
659	X Cassiopeae	49 46	+58 45.9	4.09	0.30	46 42	+58 32.5	6	9.3– 9.5	12
678	U Persei	52 56	+54 20.1	3.95	0.29	50 0	+54 7.0	6.4*	7.2– 8.2	11.6
691	W Persei	55 6	+56 15	4.03	0.29	52 6	+56 2	–	9.3	<15
715	S Arietis	1 59 16	+12 2.8	3.21	0.29	56 51	+11 49.7	2	9.1– 9.8	14?
782	R Arietis	2 10 25	+24 35.5	3.40	0.28	2 7 53	+24 22.8	1.8	7.6– 9.0	11.7–13.0
793	T Persei	12 12	+58 29.5	4.26	0.28	9 0	+58 16.7	4	8.2	9.3
806	o Ceti	14 18	− 3 25.7	3.03	0.27	12 1	− 3 38.3	5.9	1.7– 5.0	8–9.5
814	S Persei	15 41	+58 7.8	4.27	0.28	12 29	+57 55.2	5.0	8.3– 8.6	10.5–13
845	R Ceti	20 55	− 0 37.8	3.06	0.27	18 38	− 0 50.1	2.4	7.5– 8.8	13.5
869	R Fornacis	24 47	−26 32.4	2.68	0.27	22 46	−26 44.6	6 *	8.5	<10
893	U Ceti	28 56	−13 35.2	2.88	0.27	26 45	−13 47.2	3	6.8– 7.3	12
906	R Trianguli	30 59	+33 49.8	3.62	0.26	28 16	+33 37.8	5.4*	5.8– 7.1	11.7
976	T Arietis	42 45	+17 5.5	3.34	0.25	40 15	+16 54.1	3.2	7.9– 8.6	9.3– 9.7
980	V Persei	43 15	+56 34.1	4.40	0.25	39 58	+56 22.6	5.0*	7.9	9.5–10.5
1018	R Horologii	49 42	−50 21	1.98	0.25	48 13	−50 32	–	5.8– 6.2	10.0
1072	ρ Persei	2 58 46	+38 27.2	3.83	0.24	55 54	+38 16.5	2	3.4	4.2
1090	β Persei	3 1 40	+40 34.2	3.89	0.23	2 58 45	+40 23.6	0	2.3	3.5
1113	U Arietis	5 30	+14 25.3	3.32	0.23	3 3 1	+14 14.8	–	7.0– 8.5	<11
1166	X Ceti	14 20	− 1 26.0	3.05	0.22	12 3	− 1 36.0	–	9.3	<12.5
1222	R Persei	23 41	+35 19.6	3.81	0.21	20 50	+35 10.1	2.3	7.7– 9.2	12.8–13.5
1279	U Camelopardalis	33 12	+62 19.4	5.12	0.20	29 23	+62 10.4	8.0*	7.3	8.8
1357	U Eridani	46 15	−25 15.5	2.55	0.18	44 20	−25 23.8	–	8.5	11.4<
1367	X Tauri	47 50	+ 7 28.8	3.22	0.18	45 26	+ 7 20.6	–	6.6	8.1
1386	T Eridani	50 57	−24 19.5	2.56	0.18	49 2	−24 27.6	–	7.2	11.0
1411	λ Tauri	3 55 8	+12 12.5	3.32	0.17	3 52 39	+12 4.6	0	3.4	4.2
1537	T Tauri	4 16 10	+19 17.8	3.49	0.15	4 13 33	+19 11.3	0	9.2–11.5	12.8–<13.5
1574	W Tauri	4 22 15	+15 49.2	+3.42	+0.14	4 19 41	+15 42.9	5	8.0– 8.8	12.2

No.	$M-m$	Elements of Maximum, Greenwich M.T.					Basis of Elements		
		Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	M	m	Dates included
22	–	1890 Sept. 30 =	241 1640^{d}	+295^{d} E	(Pickering)		4	–	1890–95
62	–	1846 Oct. 3	239 5573	+183 E ?	(Hartwig)		6	–	1846, 73, 89–95
100	–	. . . .		. . . .	Irregularly periodic		–	–	
103	–	1855 Sept. 10	239 8837	+265.35 E	(Yendell)		5	–	1855, 78, 91–95
107	240	1871 Mar. 31	240 4515	+445 E	Periodical inequality		14	7	1842, 57, 71–94
110	–	1890 Jan. 12	241 1380	+233 E ?			4	–	1889–94
112	170:	1859 Mar. 27	240 0131	+410.7 E	+25 sin (12° E+90°)		21	1	1827, 55–93
114	145	1873 Jan. 6	240 5165	+320.2 E			9	3	1872–74, 83–95
116	–	. . . .		. . . .	New star of 1572		–	–	
146	–	. . . .		. . . .					
161	–	. . . .		. . . .	Irregular		–	–	
209	–	. . . .		. . . .	Irregular		–	–	
224	–	. . . .		. . . .	New star of 1885 in *Androm.* neb.		–	–	
243	100	1886 Dec. 12	241 0253	+276.0 E			8	3	1856, 57, 86–94
294	122:	1887 Oct. 15	241 0560	+314 E ?			3	1	1887, 94, 96
320	–	Min. 1880 June $23^{d}\,9^{h}\,28^{m}$		$+2^{d}\,11^{h}\,49^{m}\,38^{s}.25$ E	$+95^{m}$ sin (0°.08 E+283°)		–	50	1828, 80–93
401	–	1895 Nov. 2	241 3500	+280 E ?			3	–	1886, 92, 95
419	–	1894 Dec. 26	241 3189	+365 E ?			1	–	1894
432	300:	1863 Mar. 18	240 1583	+610.5 E	+50 sin (10° E+50°)		14	2	1843, 63–93
434	200:	1866 Jan. 4	240 2606	+404.3 E	Period shortening		12	1	1855, 57, 66–85, 95
466	83	1880 Jan. 8	240 7723	+172.7 E			14	11	1879–81, 84–92, 96
494	–	. . . .		207 ?	Period irregular		–	–	
513	149	1866 Nov. 22	240 2928.0	+344.15 E	+13 sin (12° E+180°)		17	2	1850, 55, 65–96
659	–	1894 Aug. 16	241 3057	+420 E ?			2	–	1894, 95
678	–	1889 Dec. 16	241 1353	+318 E ?	Large irregularities		7	–	1889–96
691	–	. . . .		. . . .			–	–	
715	165:	1872 Mar. 22	240 4867	+292.2 E	Periodic inequality		10	1	1848, 61–74, 86–93
782	91.5	1866 Sept. 4	240 2849.0	+186.55 E	+7 sin (5° E+235°)		44	22	1828–46, 58–95
793	–	. . . .		. . . .	Irregular		–	–	
806	112	1866 Dec. 27	240 2963.4	+331.6 E	Periodic inequalities.	See note	111	15	1596–1896
814	–	. . . .		. . . .	Irregularly periodic		–	–	
845	70	1867 Mar. 2	240 3028.0	+167.0 E	Periodical inequality		23	5	1794, 1841–95
869	–	. . . .		. . . .			–	–	
893	122:	1884 Dec. 11	240 9522	+235.8 E			11	1	1877, 84–95
906	119	1890 Sept. 20	241 1631	+268.0 E			7	4	1889–96
976	127	1873 Mar. 31	240 5249	+313 E			10	9	1871–74, 84–92
980	–	. . . .		. . . .			–	–	
1018	–	1889 Aug. 30	241 1245	+371 E ?			3	–	1889–91
1072	–	. . . .		. . . .	Irregularly periodic		–	–	
1090	–	Min. 1888 Jan. $3^{d}\,7^{h}\,21^{m}.5$		$+2^{d}\,20^{h}\,48^{m}\,55^{s}.425$ E	$+173^{m}.3$ sin ($\frac{1}{50}$E+202°.5)+*		–	496	1782–1887
1113	–	1892 Nov. 12	241 2415	+361 E			3	–	1892–95
1166	–	. . . .		. . . .			–	–	
1222	96	1861 Sept. 25	240 1044.0	+210.1 E	+20 sin (7°.5 E+135°)		33	5	1833, 61–95
1279	–	. . . .		. . . .	Irregular		–	–	
1357	–	. . . .		. . . .			–	–	
1367	–	. . . .		. . . .			–	–	
1386	–	1889 Nov. 3	241 1310	+253 E	(H. M. Parkhurst)		2	–	1889–96
1411	–	Min. 1887 Dec. $6^{d}\,11^{h}\,57^{m}$		$+3^{d}\,22^{h}\,52^{m}.2$ E	*Algol*-type. Periodical ineq.		–	53	1796, 1844–92
1537	–	. . . .		. . . .	Irregular		–	–	
1574	–	. . . .		. . . .	Irregularly periodic		–	–	

* $18^{m}.0$ sin ($\frac{3}{40}$E+203°.25) $+3^{m}.5$ sin ($\frac{1}{6}$E+90°.33)

No.	Star	1900.0		1900		1855.0		Red-ness	Magnitude	
		R.A.	Decl.	Annual Variation		R.A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
1577	R Tauri	4 22 19	+ 9 56.4	+3.29	+0.14	4 20 21	+ 9 50.1	4.5	7.4– 9.2	12.4–13.5
1582	S Tauri	23 43	+ 9 43.5	3.28	0.14	21 16	+ 9 37.3	2.5	9.3–10.0	<13.5
1623	T Camelopardalis	30 21	+65 56.7	5.85	0.13	25 59	+65 50.9	6 *	7.0– 8.2	<12
1635	R Reticuli	32 30	−63 14.2	0.61	0.12	32 3	−63 19.8	–	7	<13
1654	R Doradus	35 36	−62 16.4	0.70	0.12	35 5	−62 21.8	7	5.7	6.7
1662	R Caeli	37 4	−38 26	2.08	0.12	35 30	−38 31	–	7.5	10.0–10.5
1701	R Pictoris	43 29	−49 25.6	1.60	0.11	42 17	−49 30.6	–	8.1	9.5
1717	V Tauri	46 15	+17 22.1	3.47	0.11	43 39	+17 17.4	3.3	8.3– 9.4	<13.5
1764	R Orionis	53 35	+ 7 58.7	3.25	0.10	51 8	+ 7 54.3	4.9	8.7– 9.1	11.2–13.5
1768	ε Aurigae	54 47	+43 40.5	4.30	0.09	51 34	+43 36.2	1	3.0	4.5
1771	R Leporis	4 55 3	−14 57.4	2.73	0.09	53 0	−15 1.7	9.4	6–7	8.5?
1800	W Orionis	5 0 14	+ 1 2.4	3.10	0.09	57 55	+ 0 58.5	–	6	7
1803	T Leporis	0 35	−22 2.4	2.55	0.08	58 40	−22 6.3	–	8.1	10.9
1805	V Orionis	0 47	+ 3 58.0	3.16	0.09	4 58 25	+ 3 54.0	4.2*	8.4	<13
1850	S Pictoris	8 18	−48 37.7	1.59	0.07	5 7 6	−48 41.1	–	8.6	<13.3
1855	R Aurigae	9 13	+53 28.4	4.83	0.07	5 36	+53 25.0	6.5	6.5– 7.8	12.5–12.7
1894	T Columbae	15 38	−33 48.7	2.19	0.06	13 59	−33 51.6	–	7.6	11.3
1923	S Aurigae	20 31	+34 3.7	3.96	0.06	17 33	+34 2.1	6.7	9.4–11.0	<14.5
1944	S Orionis	24 5	− 4 46.4	2.96	0.05	21 51	− 4 48.7	6.4	8.3– 9.5	11.0–13.0
1953	T Aurigae	25 34	+30 22.2	3.85	0.05	22 41	+30 19.9	–	4.5	<15
1981	S Camelopardalis	30 13	+68 44.6	6.48	0.01	25 22	+68 42.5	7.8*	8.3– 8.5	10.2–12
1986	T Orionis	30 56	− 5 32.4	2.94	0.04	28 43	− 5 34.5	0	9.7	13
2013	U Aurigae	35 32	+31 59	3.90	0.04	32 37	+31 57	7.5*	8.6	12
2059	S Columbae	43 10	−31 43.7	2.25	0.02	41 29	−31 44.8	–	8.0	<10
2080	R Columbae	46 40	−29 13.2	2.32	0.02	44 55	−29 14.1	–	7.9	11.4<
2098	α Orionis	49 45	+ 7 23.3	3.25	0.02	47 19	+ 7 22.9	6	1	1.4
2100	U Orionis	49 53	+20 9.5	+3.56	+0.01	5 47 13	+20 8.7	7	6.4– 7.5	<12
2141	R Octantis	5 56 48	−86 26.0	−18.37	0.00	6 10 33	−86 25.7	–	7.4	<11.3
2170	S Leporis	6 1 38	−24 11.2	+2.47	0.00	5 59 47	−24 11.1	–	6.7– 7.1	7.4– 7.5
2213	η Geminorum	8 51	+22 32.2	+3.62	−0.01	6 6 8	+22 32.6	3	3.2	3.7– 4.2
2258	V Aurigae	16 18	+47 42.5	4.54	0.02	12 54	+47 43.5	–	8.5–10	<11.5
2266	V Monocerotis	17 41	− 2 8.7	3.02	0.03	15 25	− 2 7.6	3.4	6.3– 6.9	10.7<
2279	T Monocerotis	19 49	+ 7 8.4	3.24	0.03	17 24	+ 7 9.7	2	5.8– 6.4	7.4– 8.2
2362	R Monocerotis	33 42	+ 8 49.3	3.28	0.05	31 15	+ 8 51.7	0	9.5	13
2375	S Monocerotis	35 28	+ 9 59.3	3.31	0.05	33 0	+10 1.5	2	4.9	5.4
2445	W Monocerotis	47 30	− 7 1.6	2.91	0.07	45 19	− 6 58.6	6	8.8	<10
2478	R Lyncis	53 3	+55 28.1	4.96	0.08	49 20	+55 31.6	4.8	7.8– 8.0	<13
2509	ζ Geminorum	6 58 11	+20 43.0	3.56	0.09	55 30	+20 46.7	2	3.7	4.5
2528	R Geminorum	7 1 20	+22 51.5	3.62	0.09	58 37	+22 55.4	5.7	6.6– 7.8	<13.5
2530	V Canis minoris	1 33	+ 9 1.5	3.28	0.08	6 59 5	+ 9 5.4	–	10.3	<13.7
2539	R Canis minoris	3 13	+10 10.9	3.30	0.09	7 0 44	+10 14.9	5.5	7.2– 7.9	9.5–10.0
2583	L_2 Puppis	10 29	−44 28.8	1.82	0.10	9 7	−44 24.2	8	3.5	6.3
2610	R Canis Majoris	14 56	−16 12.4	2.70	0.11	12 55	−16 7.6	0	5.9	6.7
2625	V Geminorum	17 34	+13 17.0	3.37	0.11	15 2	+13 21.9	2.8	8.2– 9.1	12.0–14.0
2676	U Monocerotis	26 1	− 9 34.0	2.86	0.12	23 53	− 9 28.6	3	5.9– 7.3	6.6– 8.0
2684	S Canis minoris	27 18	+ 8 31.9	3.26	0.12	24 51	+ 8 37.4	4.1	7.2– 8.0	10.5–12.7
2690	X Puppis	28 27	−20 41.7	2.60	0.13	26 30	−20 36.1	–	8	9.6
2691	T Canis minoris	28 26	+11 57.5	3.34	0.12	25 56	+12 3.0	2	9.0–10.5	<13.5
2735	U Canis minoris	7 35 55	+ 8 36.8	+3.26	−0.14	7 33 28	+ 8 42.2	5.1	8.5– 9.0	12.3–13.5

No.	M — m	Elements of Maximum, Greenwich M.T.					Basis of Elements		
		Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	M	m	Dates included
1577	140:	1862 May 1=	240 1262^{d}	+325^{d} E			24	3	1798, 1855–96
1582	70:	1860 Feb. 14	240 0455.5	+375.5 E			13	1	1855–59, 83–96
1623	175:	1891 Dec. 24	241 2091	+370 E			4	1	1891–96
1635	–	1864 Feb. 5	240 1907	+280 E			5	–	1864–67, 91, 92
1654	–	. . . .		. . . . .			–	–	
1662	–	. . . .		. . . . .			–	–	
1701	–	. . . .		. . . . .			–	–	
1717	82	1872 Sept. 13	240 5050	+170.1 E		Periodic inequality	21	7	1826, 54, 71–96
1761	214:	1855 Mar. 23	239 8666	+380.0 E			12	2	1846–74, 83–94
1768		. . . .		. . . . .		Irregular	–	–	
1771	212	1864 Mar. 5	240 1936.7	+436.1 E		Periodical inequality	20	13	1855–83, 94
1800	–	. . . .		. . . . .			–	–	
1803	–	1889 Dec. 6	241 1343	+360 E ?			5	–	1889–95
1805	120:	1891 Feb. 14	241 1778	+266 E ?			3	2	1891–96
1850	–	1894 Nov. 5	241 3138	+410 E ?			3	–	1892–94
1855	248	1862 Nov. 17	240 1462	+460.2 E			17	6	1862–74, 79–94
1894	–	1889 Oct. 6	241 1282	+218 E			6	–	1873–95
1923	–	. . . .		. . . . .		Irregularly periodic	–	–	
1944	194	1870 Feb. 1	240 4095	+413 E			13	6	1863–75, 83–96
1953		. . . .		. . . . .		New star of 1892	–	–	
1981	169	1892 July 29	241 2309	+313 E			5	4	1859, 92–95
1986	–	. . . .		. . . . .		Irregular	–	–	
2013	–	1891 Jan. 17	241 1750	+407 E			5	–	1891–94
2059	–	. . . .		. . . . .			–	–	
2080	–	1894 Dec. 27	241 3190	+164 E ?		(Hartwig)	1	–	1894
2098	–	. . . .		. . . . .		Irregularly periodic	–	–	
2100	145:	1885 Dec. 1	240 9877	+375 E			11	1	1885–96
2141	–	. . . .		. . . . .			–	–	
2170	–	. . . .		. . . . .		Irregularly periodic	–	–	
2213	–	Min. 1865 Nov. 5		+231.4 E		Periodic inequality	–	14	1844, 65–81
2258	122:	1886 Dec. 14	241 0255	+313 E			6	2	1886–95
2266	–	1883 Feb. 11	240 8853	+332.0 E			8	–	1853, 83–94
2279	7.93	1885 Apr. 1	240 9633.63	+ 27.0122 E		(Yendell)	–	–	
2362	–	. . . .		. . . . .		Irregular	–	–	
2375	–	. . . .		. . . . .			–	–	
2445	–	1887 Dec. 11	241 0617	+262.5 E ?		(Hartwig)	3	–	1887, 95
2478	143	1874 Sept. 15	240 5782	+380.0 E			10	3	1874, 84–95
2509	5.015	1888 Jan. 3	241 0640.603	+ 10.15382 E			–	–	
2528	121	1868 Feb. 7	240 3370.0	+370.2 E	+35 sin (6° E+78°)		21	9	1796, 1855–94
2530	–	1889 Sept. 20	241 1266	+364 E		(Pickering)	3	–	1889–95
2539	130:	1859 Feb. 13	240 0089	+337.7 E			19	2	1796, 1822, 59–95
2583	69	1872 Mar. 20	240 4873	+140.0 E			9	2	1872–74, 86–92
2610	–	Min. 1887 Mar. 26^{d} 15^{h} 18^{m}		+1^{d} 3^{h} 15^{m} 46^{s}.0 E		*Algol*-type	–	23	1887–93
2625	132	1880 Feb. 8	240 7754	+276 E			12	3	1857, 80–86, 92–95
2676	18.0	1873 Apr. 26	240 5275	+ 46.10 E		Periodic inequality	44	37	1873, 74, 81–95
2684	164	1863 May 3	240 1629	+330.3 E	+20 sin (12° E+30°)		17	2	1856–75, 83–95
2690	–	. . . .		. . . . .			–	–	
2691	–	1870 Mar. 16	240 4138	+322.7 E		Periodic inequality	10	–	1854, 70–73, 83–94
2735	175	1880 Feb. 14=	240 7760	+410 E			6	8	1880–95

No.	Star	1900.0 R.A.	1900.0 Decl.	1900 Annual Variation		1855.0 R.A.	1855.0 Decl.	Redness	Magnitude Max.	Magnitude Min.
		h m s	° ′	s	′	h m s	° ′			
2742	S Geminorum	7 37 3	+23 41.1	+3.61	−0.14	7 34 20	+23 47.2	3	8.2– 8.7	<13.5
2776	W Puppis	42 39	−41 57.4	1.99	0.14	41 9	−41 50.6	–	9.5	12.0
2780	T Geminorum	43 18	+23 59.0	3.61	0.15	40 36	+24 5.5	3.0	8.1– 8.7	<13.5
2783	S Puppis	43 50	−47 51.9	1.74	0.15	42 31	−47 45.4	–	7.2	9
2815	U Geminorum	49 10	+22 15.8	3.56	0.15	46 30	+22 22.7	0.0	8.9– 9.7	13.4
2852	V Puppis	55 22	−48 58.4	1.73	0.16	54 4	−48 51.2	–	4.4	5.2
2857	U Puppis	7 56 8	−12 33.8	2.81	0.16	7 54 2	−12 26.6	3.2	8.5– 9.0	<14
2946	R Cancri	8 14 3	+12 2.0	3.32	0.18	8 8 34	+12 10.1	5.3	6.0– 8.3	<11.7
2976	V Cancri	16 1	+17 36.1	3.43	0.19	13 27	+17 44.5	4.3	6.8– 7.7	<12
3040	V Carinae	26 41	−59 47.3	1.24	0.20	25 46	−59 38.3	–	7.2	8.0
3055	X Carinae	29 7	−58 53.2	1.31	0.20	28 8	−58 44.1	–	7.8	8.6
3060	U Cancri	30 3	+19 14.4	3.44	0.20	27 28	+19 23.5	2.3	8.4–10.6	<14
3087	T Velorum	34 26	−47 0.7	1.95	0.21	32 58	−46 51.3	–	7.5	8.5
3109	S Cancri	38 14	+19 23.6	3.44	0.21	35 39	+19 33.2	1	8.2	9.8
3128	R Pyxidis	41 17	−27 50.2	2.53	0.22	39 23	−27 40.5	6	8.0	<11
3170	S Hydrae	48 21	+ 3 26.7	3.13	0.22	46 0	+ 3 36.8	2.1	7.5– 8.7	<12.2
3184	T Hydrae	50 48	− 8 45.6	2.92	0.23	48 37	− 8 35.4	1.8	7.0– 8.1	<13
3186	T Cancri	8 50 57	+20 13.9	3.43	0.23	8 48 23	+20 24.1	7.4	8.0– 8.5	9.3–10.5
3264	W Cancri	9 4 0	+25 39	3.52	0.24	9 1 21	+25 50	–	9.6	<13
3355	W Carinae	19 15	−55 32.0	1.82	0.26	17 53	−55 20.5	–	7.5	8.5
3407	S Antliae	27 56	−28 11.2	2.63	0.26	25 57	−27 59.4	0	6.7	7.3
3409	N Velorum	28 11	−56 35.6	1.83	0.26	26 49	−56 23.8	2	3.4	4.4
3416	S Velorum	29 27	−44 45.9	2.26	0.26	27 45	−44 34.1	–	7.8	9.3
3417	U Velorum	29 28	−45 4.3	2.25	0.26	27 46	−44 52.4	–	8.1	8.5
3418	R Carinae	29 44	−62 20.8	1.52	0.26	28 36	−62 8.9	5	4.3– 5.7	9.3–10.0
3425	X Hydrae	30 44	−14 14.7	2.87	0.27	28 35	−14 2.8	–	8.4	11.8
3467	R Sextantis	37 46	− 7 38.7	2.97	0.27	35 33	− 7 26.5	–	9.7	10.6
3477	R Leonis minoris	39 35	+34 58.3	3.61	0.27	36 52	+35 10.6	6.0	6.1– 7.8	13
3493	R Leonis	42 11	+11 53.6	3.23	0.28	39 45	+12 5.9	6.9	5.2– 6.7	9.4–10.0
3495	*l* Carinae	42 30	−62 2.8	1.65	0.28	41 16	−61 50.4	–	3.7	5.2
3567	V Leonis	54 28	+21 44.5	3.36	0.29	51 57	+21 57.3	1.7	8.6	<13.5
3569	RR Carinae	9 54 50	−58 23.0	1.94	0.29	9 53 23	−58 10.2	–	8.2	9.6
3633	R Antliae	10 5 27	−37 14.4	2.59	0.29	10 3 30	−37 1.2	–	6.5	<8
3637	S Carinae	6 11	−61 3.6	1.92	0.29	4 45	−60 50.4	5	6.0	9.0– 9.2
3662	Z Carinae	10 24	−58 21	2.07	0.30	8 51	−58 8	–	9.4	12.1
3712	U Leonis	18 42	+14 30.6	3.22	0.30	16 17	+14 44.1	–	9.5	<13.5
3767	Y Carinae	29 25	−57 59.0	2.25	0.31	27 44	−57 45.1	–	7.8	8.6
3796	U Hydrae	32 37	−12 51.9	2.96	0.31	30 24	−12 38.1	7	4.5	6.1– 6.3
3825	R Ursae Majoris	37 34	+69 18.0	4.32	0.31	34 19	+69 32.1	1.6	6.0– 8.2	12.6–13.2
3847	η Carinae	41 11	−59 9.5	2.32	0.31	39 27	−58 55.4	5	>1	7.4
3881	V Hydrae	46 46	−20 43.2	2.91	0.32	44 34	−20 28.8	9	6.7	9.5
3890	W Leonis	48 21	+14 14.9	3.18	0.32	45 58	+14 29.2	3.5*	9	<14
3908	T Carinae	51 18	−59 54.2	2.39	0.32	49 30	−59 44.8	–	6.2	6.9
3922	U Carinae	53 44	−59 11.8	2.43	0.32	51 54	−58 57.4	–	6.7	8.5
3934	R Crateris	10 55 38	−17 47.3	2.95	0.32	10 53 26	−17 32.8	8.1	>8	<9
3983	RS Carinae	11 3 54	−61 23.6	2.48	0.32	11 2 3	−61 9.0	–	8	11
3994	S Leonis	5 41	+ 6 0.2	3.11	0.32	3 21	+ 6 14.9	0.0	9.0–10.0	<13
4160	T Leonis	33 19	+ 3 55.5	3.08	0.33	31 0	+ 4 10.5	–	10	<13.5
4225	X Centauri	11 44 12	−41 11.9	+2.99	−0.33	11 41 57	−40 56.9	–	7.8	12.4

No.	$M-m$	Elements of Maximum, Greenwich M.T.					Basis of Elements		
		Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	M	m	Dates included
2742	127:	1852 Feb. 27 =	239 7546^d	+294^d E			20	1	1848–73, 86–94
2776	–	. . . . . .	. . . . .	. . . . .			–	–	
2780	–	1848 Dec. 7	239 6369.5	+288.1 E			17	–	1848–71, 86–96
2783	–	. . . . . .	. . . . .	. . . . .			–	–	
2815	–	1895 Oct. 28	241 3495	+ 86.3 E	Large irregularities		–	–	
2852	–			2.25	(Roberts)		–	–	
2857	–	1881 Mar. 8	240 8148	+315 E			5	–	1881–83, 93
2946	125:	1852 Apr. 21	239 7600.1	+352.81 E	+0.207 E^2		19	1	1830, 52–85, 95
2976	110	1871 May 20	240 4568	+272.1 E			12	3	1855, 71–75, 83–95
3040	3.0			6.66	(Roberts)		–	–	
3055	0.27	1893 Feb. 22	241 2517.23	+ 0.5413368 E	(Roberts)		–	–	
3060	–	1853 Apr. 18	239 7962	+305.0 E			16	–	1853–59, 69–95
3087	1.8			4.6	(Roberts)		–	–	
3109	–	MIN. 1867 Aug. 31^d 14^h 2^m.89		+9^d 11^h 37^m 45^s E	(Schönfeld)	*Algol*-type	–	–	
3128	–	1889 Dec. 13	241 1350	+355 E ?			9	–	1851,80, 89–95
3170	–	1857 Feb. 13	239 9359	+257.0 E	Periodic inequality		17	–	1852–86, 94, 95
3184	–	1858 Feb. 28	239 9739	+288.8 E			19	–	1851–73, 84. 92, 95
3186	–	MIN. 1858 Jan. 26	239 9706	+482 E			–	10	1858–75, 84, 87, 95
3264	–	1890 Nov. 22	241 1694	+381 E ?			3	–	1890–95
3355	0.9			4.38	(Roberts)		–	–	
3407	–	MIN. 1888 Apr. 13^d 12^h 38^m.0		+0^d 7^h 16^m 48^s.0 E	*Algol*-type		–	15+	1888–95
3409	–	. . . . . .	. . . . .	. . . . .	Short period		–	–	
3416	–	MIN. 1894 May 1^d 8^h 22^m.5		+5^d 22^h 24^m.35 E	(Roberts)	*Algol*-type	–	–	1894, 95
3417	–			65	(Roberts)		–	–	1895
3418	136	1871 Aug. 13	240 4653	+309.5 E	+25 sin (9° E +279°)		18	8	1752, 1867–95
3425	–	1892 Mar. 22	241 2180	+296 E	(Paul)		2	1	1895, 96
3467	–	. . . . . .	. . . . .	. . . . .	Variability doubtful		–	–	
3477	170	1865 Mar. 12	240 2308.0	+370.5 E	+20 sin (10° E+300°)		18	5	1796, 1865–95
3493	144	1757 Apr. 26	236 2907	+312.8 E	Periodic inequality.	See note	50	16	1757–1896
3495	15	1871 July 24	240 4633.0	+ 35.05 E			24	7	1871–74, 91, 92
3567	–	1882 Apr. 2	240 8538	+273.7 E			7	–	1855, 82–94
3569	–	. . . . . .	. . . . .	. . . . .			–	–	
3633	–	. . . . . .	. . . . .	. . . . .			–	–	
3637	86	1872 May 8	240 4922	+148.7 E			4	3	1872–80, 91
3662	–	. . . . . .	. . . . .	. . . . .			–	–	
3712	–	. . . . . .	. . . . .	. . . . .	Variability very doubtful		–	–	
3767	0.92	1894 Feb. 9	241 2869.2	+ 3.637 E	(Roberts)		–	–	
3796	–	. . . . . .	. . . . .	. . . . .	Irregularly periodic		–	–	
3825	107	1853 Apr. 7	239 7951.2	+302.1 E	+15 sin (10° E+190°)		41	17	1843–95
3847	–	. . . . . .	. . . . .	. . . . .	Irregular		–	–	
3881		. . . . . .	. . . . .	. . . . .	Period long and irregular		–	–	
3890	–	. . . . . .	. . . . .	. . . . .	Period in doubt		–	–	
3908	–	. . . . . .	. . . . .	. . . . .	Period probably very short		–	–	
3922	6.0	1892 Feb. 1	241 2130	+ 38.6 E	(Roberts)		–	–	
3934	–	. . . . . .	. . . . .	. . . . .	Variability not certain		–	–	
3983	–	. . . . . .	. . . . .	. . . . .	"New star" (?)		–	–	
3994	125:	1860 Dec. 1	240 0746	+190.0 E	+25 sin (10° E+60°)		19	1	1859–95
4160	–	. . . . . .	. . . . .	. . . . .			–	–	
4225	140	1889 May 27 =	241 1150	+314 E ?			4	2	1889–95

No.	Star	1900.0		1900		1855.0		Redness	Magnitude	
		R.A.	Decl.	Annual Variation		R.A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
4260	W Centauri	11 50 2	−58 41.8	+2.98	−0.33	11 47 49	−58 26.8	–	8.6	13.0
4300	X Virginis	56 44	+ 9 37.7	3.08	0.33	54 25	+ 9 52.7	–	8–10	12
4315	R Comae	11 59 7	+19 20.3	3.08	0.33	11 56 49	+19 35.4	4.0	7.4– 8.0	<13.5
4364	S Muscae	12 7 24	−69 35.7	3.19	0.33	12 5 1	−69 20.7	–	6.5	7.3
4377	T Virginis	9 29	− 5 28.8	3.08	0.33	7 10	− 5 13.8	4.1	8.0– 8.8	10–<13.5
4407	R Corvi	14 27	−18 42.0	3.10	0.33	12 8	−18 26.9	3.7	6.8– 7.7	<11.5
4415	T Crucis	15 54	−61 43.6	3.24	0.33	13 28	−61 28.6	–	6.8	7.6
4429	R Crucis	18 8	−61 4.5	3.26	0.33	15 42	−60 49.5	–	6.8	8.0
4435	S Centauri	19 12	−48 53.2	3.20	0.33	16 48	−48 38.2	–	7	?
4488	U Centauri	28 0	−54 6.3	3.30	0.33	25 32	−53 51.3	–	9.2	11.3
4492	Y Virginis	28 44	− 3 52.3	3.08	0.33	26 25	− 3 37.3	3.6	8– 9.4	11.5–13
4511	T Ursae Majoris	31 50	+60 2.3	2.75	0.33	29 47	+60 17.2	2.0	6.0– 8.5	12.2–13.0
4521	R Virginis	33 26	+ 7 32.3	3.05	0.33	31 9	+ 7 47.2	1.3	6.5– 8.0	9.7–11.0
4536	R Muscae	35 58	−68 51.5	3.61	0.33	33 17	−68 36.7	–	6.6	7.4
4557	S Ursae Majoris	39 34	+61 38.4	2.63	0.33	37 35	+61 53.3	3.2	6.7– 8.2	10.2–11.5
4596	U Virginis	46 1	+ 6 5.8	3.04	0.33	43 45	+ 6 20.6	1.1	7.7– 8.1	12.2–12.8
4611	S Crucis	12 48 27	−57 53.3	3.52	0.33	12 45 49	−57 38.5	–	6.6	7.8
4731	S Canum Venat.	13 8 31	+37 54.5	2.77	0.32	13 6 24	+38 8.9	6.3*	7.3	9
4805	W Virginis	20 52	− 2 51.5	3.09	0.31	18 33	− 2 37.4	0.4	8.7– 9.2	9.8–10.4
4816	V Virginis	22 38	− 2 39.2	3.09	0.31	20 19	− 2 25.2	2.7	8.0– 9.0	<13
4826	R Hydrae	24 15	−22 45.9	3.27	0.31	21 48	−22 31.8	5.9	3.5– 5.5	9.7
4847	S Virginis	27 47	− 6 40.8	3.43	0.31	25 26	− 6 26.8	2.6	5.7– 8.0	12.5
4885	Z Centauri	34 17	−31 7.6	3.39	0.31	31 44	−30 53.8	–	7.2	11.5<
4896	T Centauri	36 2	−33 5.5	3.43	0.31	33 28	−32 51.7	–	5.9	9.2
4940	W Hydrae	43 23	−27 52.0	3.38	0.30	40 51	−27 38.5	8.2*	6.7	8.0
4948	R Canum Venat.	44 39	+40 2.4	2.58	0.30	42 43	+40 15.9	–	6.1– 7.0	11.5
5037	RR Virginis	13 59 35	− 8 43.1	3.17	0.29	13 57 12	− 8 30.0	–	11–12	<14
5070	Z Virginis	14 4 58	−12 49.8	3.23	0.29	14 2 33	−12 36.5	–	9.5–11	<14
5095	R Centauri	9 22	−59 26.9	4.28	0.28	6 10	−59 14.1	6	6.0– 6.3	8.7– 9.8
5097	T Bootis	9 25	+19 32.0	2.82	0.28	7 18	+19 44.7	–	9.7 ?	<13
5134	T Lupi	15 43	−49 23.5	3.94	0.28	12 46	−49 11.0	–	9.2	11.2
5144	Y Bootis	17 22	+20 15.8	2.79	0.28	15 16	+20 28.2	–	8.0	8.6
5156	X Bootis	19 27	+16 46.4	2.84	0.27	17 19	+16 58.8	4	9.0– 9.4	10.2
5157	S Bootis	19 32	+54 15.9	2.04	0.27	18 1	+54 28.3	2.8	7.7– 8.5	12.5–13.2
5174	RS Virginis	22 16	+ 5 7.6	+3.00	0.27	20 1	+ 5 19.9	–	8.2	12 ?
5190	R Camelopardalis	25 6	+84 17.1	−4.83	0.27	28 54	+84 29.2	2.1	7.2– 8.6	11.8–13.5
5191	Y Centauri	25 5	−29 39.1	+3.52	0.27	22 27	−29 26.9	–	7.7	8.8
5192	V Centauri	25 23	−56 26.7	4.27	0.27	22 12	−56 14.5	–	6.7	7.6
5194	V Bootis	25 42	+39 18.5	2.42	0.27	23 54	+39 30.4	3.6	6.9– 7.6	9.0–10.5
5237	R Bootis	32 47	+27 10.2	2.65	0.26	30 48	+27 22.1	2.7	5.9– 7.8	11.3–12.2
5249	V Librae	34 48	−17 13.6	3.33	0.26	32 18	−17 1.8	–	9.3	12.2
5274	W Bootis	39 2	+26 57.2	2.64	0.26	37 3	+27 8.9	–	5.2	6.1
5319	R Apodis	46 28	−76 15.3	6.70	0.26	41 30	−76 4.0	–	5.5	6.2
5321	S Lupi	46 42	−46 12	4.00	0.25	43 42	−46 1	–	9.7	<12
5338	U Bootis	49 42	+18 6.0	2.78	0.25	47 37	+18 17.1	2.7	9.1–10.0	12–13.6
5374	δ Librae	55 38	− 8 7.3	3.20	0.24	53 14	− 7 56.4	1	5.0	6.2
5396	S Apodis	14 59 21	−71 40.4	5.92	0.24	54 57	−71 29.6	–	9.0	<11.4
5402	T Triang. Austr.	15 0 24	−68 20.1	5.46	0.24	56 20	−68 9.4	–	6.9	7.4
5405	RT Librae	15 0 47	−18 20.8	+3.39	−0.24	14 58 15	−18 10.1	–	8.5	11.7<

No.	$M-m$	Elements of Maximum, Greenwich M.T. Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	Basis of Elements M	m	Dates included
4260	–	1889 Apr. 18	241 1111^{d}	+370^{d} E ?			4	–	1889–95
4300	–	. . . .	. . . . .	. . . . .			–	–	
4315	–	1856 Dec. 10	239 9294	+361.8 E			9	–	1831, 56, 83–95
4364	3.5	1892 Jan. 3	241 2101.6	+ 9.66 E		(Roberts)	–	–	
4377	–	1861 Apr. 26	240 0891	+339.5 E			8	2	1861–75, 84–95
4407	–	1868 May 23	240 3476	+318.5 E			12	–	1851, 68–75, 83–95
4415	2.73	. . . .	. . . . .	6.669		(Roberts)	–	–	
4429	1.4	1891 Dec. 25	241 2092.0	+ 5.827		(Roberts)	–	–	
4435	–	. . . .	. . . . .	. . . . .		Variability not certain	–	–	
4488	–	. . . .	. . . . .	. . . . .			–	–	
4492	85:	1883 Mar. 10	240 8880	+218.8 E			4	2	1882–93
4511	107.5	1860 Oct. 21	240 0705.8	+257.2 E	$+20\sin(9^\circ E+90^\circ)$		38	14	1843, 60–95
4521	68.5	1809 June 0	238 1934.8	+145.47 E	$+20\sin(\frac{9}{5}{}^\circ E+216^\circ)+4.8\sin(\frac{4}{8}{}^{5\circ}+343^\circ)$		76	27	1809–95
4536	0.295	1871 Aug. 16	240 1656.656	+0.882 253 E			19	15	1871–92
4557	113.0	1860 June 24	240 0586.0	+226.1 E	$+43\sin(5^\circ.76\,E+181^\circ.5)$		59	37	1790, 1843–95
4596	88	1866 June 25	240 2778.0	+207.0 E		Periodic inequality	22	7	1813–31, 57–95
4611	1.5	1892 Jan. 2	241 2100.4	+ 4.692 E		(Roberts)	–	–	
4731	–	. . . .	. . . . .	. . . . .		Variability somewhat doubtful	–	–	
4805	8.20	1866 Apr. 16	240 2708.2666	+17.2711 E			41	45	1866–72, 89–92
4816	–	1860 Feb. 15	240 0456.5	+250.5 E			16	–	1857–75, 83–94
4826	190	1891 July 17	241 1931.0	+425.15 E	$-0.36\,E^2+15\sin(7^\circ.5\,E+202^\circ)$		24	6	1784–1890
4847	157:	1852 Jan. 24	239 7512	+376.4 E	$+20\sin(7^\circ.5\,E+180^\circ)$		19	2	1795, 1824, 52–95
4885	–	1885 Apr. 12	240 9644	+374 E??		See note	–	–	1885–96
4896	42	1895 June 9	241 3354	+ 91.2 E		(Roberts)	3	3	1894, 95
4940	–	1889 Feb. 27	241 1061	+384 E			7	–	1875, 89–94
4948	–	1888 Mar. 21	241 0718	+338 E			7	–	1858, 85–94
5037	–	1879 May 13	240 7483	+217 E			9	–	1873, 79–95
5070	–	1880 May 25	240 7861	+306.5 E			8	–	1855, 80–95
5095	60:	1871 May 25	240 4573	+160.5 E			8	3	1871–78, 91, 92
5097	–	. . . .	. . . . .	. . . . .		Only one appearance known	–	–	
5134	–	. . . .	. . . . .	. . . . .			–	–	
5144	–	. . . .	. . . . .	2.6		*Algol*-type ?	–	–	
5156	–	. . . .	. . . . .	121.5			–	–	
5157	126	1863 May 10	240 1636	+268.2 E	$+0.246\,E^2-0.005\,E^3$		35	10	1865–95
5174	–	1890 May 22	241 1510	+360 E			6	–	1890–95
5190	120:	1869 Aug. 29	240 3939	+269.5 E			35	11	1862–95
5191	–	. . . .	. . . . .	. . . . .		Variability somewhat doubtful	–	–	
5192	2.50	1894 July 27	241 3037.03	+ 5.543 E		(Roberts)	–	–	
5194	97	1884 Aug. 30	240 9419	+256 E		(Dunér)	10	5	1884–95
5237	101.5	1858 June 8	239 9839	+223.4 E	$+10\sin(10^\circ E+80^\circ)$		33	17	1858–95
5249	–	1882 Apr. 30	240 8566	+360 E ?			3	–	1880–94
5274	–	. . . .	. . . . .	. . . . .		Irregular	–	–	
5319	–	. . . .	. . . . .	. . . . .			–	–	
5321	–	1891 Aug. 1	241 1946	+345 E ?			3	–	1891–94
5338	95	1880 Mar. 11	240 7786	+176.7 E			12	9	1857, 80–95
5374	–	Min. 1867 Oct. $25^{d}\ 9^{h}\ 17^{m}.5$		$+2^{d}\ 7^{h}\ 51^{m}\ 22^{s}.8$ E		*Algol*-type	–	93	1797, 1837–88
5396	–	. . . .	. . . . .	. . . . .			–	–	
5402	–	. . . .	. . . . .	0.98			–	–	
5405	–	. . . .	. . . . .	. . . . .			–	–	

No.	Star	1900.0		1900		1855.0		Redness	Magnitude	
		R.A.	Decl.	Annual Variation		R.A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
5430	T Librae	15 5 2	−19 38.3	+3.42	−0.23	15 2 28	−19 27.8	–	9.2–10.2	<14.7
5438	Y Librae	6 24	− 5 38.0	3.17	0.23	4 2	− 5 27.6	–	8.2– 8.7	12
5465	R Triang. Austr.	10 49	−66 7.7	5.31	0.22	6 52	−65 57.5	–	6.6– 6.8	7.5– 8.0
5484	U Coronae	14 7	+32 0.8	2.45	0.22	12 17	+32 10.8	0.0	7.5	8.9
5494	S Librae	15 39	−20 1.6	3.44	0.22	13 4	−19 51.7	3.0	7.6– 8.3	<13
5501	S Serpentis	16 59	+14 40.1	2.81	0.22	14 52	+14 50.3	4.1	7.6– 8.7	12.5?
5504	S Coronae	17 19	+31 43.6	2.45	0.22	15 29	+31 53.5	4.9	6.1– 7.8	11.9–12.5
5511	RS Librae	18 29	−22 33.2	3.50	0.22	15 52	−22 23.4	–	8.2	13
5533	R Normae	22 14	−50 13.9	4.31	0.21	18 57	−50 4.4	–	7	13
5566	RU Librae	27 44	−14 59.1	3.35	0.21	25 10	−14 50.0	–	8.5	<12
5583	X Librae	30 26	−20 50.0	3.48	0.20	27 50	−20 40.8	–	9.5– 9.9	14
5593	W Librae	32 12	−15 50.6	+3.37	0.20	29 40	−15 41.5		9.8	<14
5601	S Ursae minoris	33 27	+78 58.3	−2.46	0.20	35 19	+79 7.2	7	7.4	11.5
5617	U Librae	36 13	−20 51.5	+3.48	0.20	33 37	−20 42.6	3.4	9	<14
5644	Z Librae	40 42	−20 48.8	3.49	0.19	38 5	−20 40.1	–	11	<13
5667	R Coronae	44 27	+28 27.8	2.47	0.19	42 36	+28 36.3	0.5	5.8	13.0
5675	V Coronae	45 57	+39 52.3	2.14	0.18	44 21	+40 0.7	5.9	7.2– 7.7	10.3–12.0
5677	R Serpentis	46 5	+15 26.3	2.76	0.18	44 1	+15 34.6	3.7	5.6– 7.6	13
5682	R Lupi	46 59	−35 59.9	3.88	0.18	44 5	−35 51.6	–	9	<11
5688	R Librae	47 56	−15 56.3	3.39	0.18	45 24	−15 48.1	2	9.2–10.0	<13
5704	RR Librae	50 39	−18 0.7	3.44	0.18	48 4	−17 52.6	3	8.4	14
5713	S Triang. Austr.	52 12	−63 29.5	5.35	0.18	48 12	−63 21.4		6.5	7.5
5732	T Coronae	55 19	+26 12.2	2.51	0.17	53 26	+26 20.1	1	2.0	9.5
5750	U Triang. Austr.	58 25	−62 38.3	5.30	0.17	54 27	−62 30.6	–	7.7	8.7
5758	X Herculis	15 59 39	+47 30.8	1.81	0.17	58 17	+47 38.4	7	5.9– 6.3	6.8– 7.2
5761	Z Scorpii	16 0 8	−21 27.7	3.53	0.17	15 57 29	−21 20.1	–	9.0– 9.5	12?
5768	RR Herculis	1 28	+50 46.3	1.65	0.17	16 0 11	+50 51.2	6.3*	7.8	9.5
5770	R Herculis	1 44	+18 38.4	2.68	0.16	15 59 43	+18 45.9	2.0	8.0– 9.2	<13
5776	X Scorpii	2 40	−21 15.6	3.53	0.16	16 0 2	−21 8.3	–	10	<13
5795	W Scorpii	5 55	−19 52.6	3.50	0.16	3 18	−19 45.3	–	10–11.2	<14.7
5823	S Normae	10 35	−57 39.2	4.95	0.15	6 52	−57 32.1	–	6.5	7.4
5826	T Scorpii	11 5	−22 43.6	3.57	0.15	8 25	−22 36.7	–	7.0	<12
5830	R Scorpii	11 41	−22 41.9	3.57	0.15	9 1	−22 35.0	0.9	9.4–10.5	<13
5831	S Scorpii	11 42	−22 39.0	3.57	0.15	9 2	−22 32.0	0	9.1–10.5	<13
5856	W Ophiuchi	16 2	− 7 27.5	3.23	0.15	13 36	− 7 21.3	6	8.9– 9.5	<13.5
5860	U Scorpii	16 45	−17 38.5	3.46	0.15	14 10	−17 31.9	–	9?	<12
5887	V Ophiuchi	21 10	−12 12.0	3.33	0.14	18 40	−12 5.5	6.6	7.0– 7.5	9.6–10.5
5889	U Herculis	21 22	+19 7.2	2.65	0.14	19 23	+19 13.6	6.5	6.6– 7.8	11.4–12.7
5903	Y Scorpii	23 49	−19 13.3	3.50	0.14	21 12	−19 7.1	–	10?	14
5912	η Herculis	25 21	+12 6.1	1.97	0.13	23 53	+12 12.2	3	4.7– 5.5	5.4– 6.0
5928	T Ophiuchi	28 1	−15 55.2	3.42	0.13	25 27	−15 49.2	–	10	<12.5
5931	S Ophiuchi	28 30	−16 57.0	+3.45	0.13	25 55	−16 51.1	1	8.3– 9.0	<13
5948	R Ursae minoris	31 18	+72 28	−0.84	0.13	31 57	+72 34.4	3.2	8.6– 9.0	10.0–10.5
5949	R Arae	31 26	−56 47.6	+4.96	0.13	27 43	−56 41.8	–	6.9	8.0
5950	W Herculis	31 44	+37 32.4	2.13	0.13	30 5	+37 38.1	3.2	8.0– 8.4	11.5–14
5952	Y Herculis	32 0	+ 7 18.6	2.91	0.13	29 50	+ 7 23.3	–	6.9	8.0
5955	R Draconis	32 23	+66 57.8	0.14	0.12	32 17	+67 3.5	2.0	6.5– 8.7	12–13
6005	S Draconis	40 46	+55 7.2	1.27	0.11	39 49	+55 11.8	7.0*	7.5– 8.2	9.3
6044	S Herculis	16 47 21	+15 6.6	+2.73	−0.10	16 45 18	+15 11.1	5.6	5.9– 7.5	11.5–13

No.	$M-m$	Elements of Maximum, Greenwich M.T.					Basis of Elements		
		Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	M	m	Dates included
5430	105	1878 Apr. 30	240 7105$^{\mathrm{d}}$	+238$^{\mathrm{d}}$ E			5	3	1878–92
5438	–	1861 June 22	240 0949	+272 E ?			6	–	1861, 78, 87 95
5465	0.83	1871 July 14	240 4623.71	+ 3.38922 E			–	–	1871, 72. 91
5484	–	Min. 1870 Mar.	$25^{\mathrm{d}}\ 10^{\mathrm{h}}\ 38^{\mathrm{m}}.5$	$+3^{\mathrm{d}}\ 10^{\mathrm{h}}\ 51^{\mathrm{m}}\ 12^{\mathrm{s}}.4\ \mathrm{E} - 0.0018\ \mathrm{E}^2$		*Algol*-type	–	37	1858–89
5494	–	1874 June 17	240 5692	+192.1 E			10	–	1856, 74, 83–95
5501	–	1828 Apr. 2	238 8815	+365.4 E	+60 sin (6°.5 E +347°)		32	–	1794, 1828–95
5501	116	1860 Aug. 24	240 0647	+360.8 E			29	10	1860–93
5511	–	1889 July 6	241 1190	+221 E			5	–	1889–95
5533	–	. . . . . .	. . . . .	. . . . .		"New" star of 1893	–	–	
5566	–	1888 June 11	241 0800	+320 E ?			3	–	1888–95
5583	80	1878 July 17	240 7183	+163.6 E			15	1	1878–95
5593	–	1878 May 27	240 7132	+206 E			9	–	1878–92
5601	–	1890 Sept. 4	241 1615	+328 E			4	–	1890–96
5617	–	1873 July 23	240 5363	+226.2 E		Periodic inequality ?	11	–	1849, 73–93
5644	–	1878 May 4	240 7109	+295 E			5	–	1878–86, 94
5667	–	. . . . . .	. . . . .	. . . . .		Irregular	–	–	
5675	171	1878 Oct. 21	240 7279	+356.5 E			15	5	1857–61, 78–95
5677	151	1827 May 22	238 8499	+357.0 E	+35 sin (4° E+48°)		33	7	1783, 1827–95
5682	–	. . . . . .	. . . . .	. . . . .			–	–	
5688	–	. . . . . .	. . . . .	. . . . .		2 yrs. period doubtful	–	–	
5704	–	1885 June 17	240 9710	+277.0 E			6	–	1851, 85–94
5713	–	. . . . . .	. . . . .	6.3		(Roberts)	–	–	
5732	–	. . . . . .	. . . . .	. . . . .		New star of 1866	–	–	
5750	0.76	1891 Feb. 7	241 2867.7	+ 2.546 E		(Roberts)	–	–	
5758	60	1890 July 4	241 1553	+ 92.5 E		Large irregularities	10	11	1890–94
5761	–	1873 May 13	240 5292	+370 E			11	–	1854, 73–95
5768	–	. . . . . .	. . . . .	. . . . .			–	–	
5770	–	1865 July 18	240 2436	+317.7 E	+20 sin (12° E+324°)		23	–	1825, 56–94
5776	–	1876 Apr. 19	240 6364	+199.0 E			10	–	1876–88, 91, 94
5795	146:	1876 May 26	240 6401	+222.3 E			12	2	1876–93
5823	–	. . . . . .	. . . . .	9.75		(Roberts)	–	–	
5826	–	. . . . . .	. . . . .	. . . . .		New star of 1860 in *Messier* 80	–	–	
5830	–	1863 Mar. 25	240 1590.5	+224.5 E		Periodic inequality	24	–	1837–53, 63–94
5831	–	1837 June 1	239 2162.4	+176.7 E			26	–	1837, 39, 54–95
5856	–	1881 July 10	240 8272	+331.3 E			5	–	1823, 81–93
5860	–	. . . . . .	. . . . .	. . . . .		Only one appearance known	–	–	
5887	176:	1874 May 26	240 5670	+302.5 E			10	2	1874–95
5889	167	1860 Nov. 8	240 0723	+409 E		Periodic inequality ?	16	6	1860–85, 93
5903	–	1876 June 26	240 6432	+359 E ?			3	–	1876, 80, 83
5912	–	. . . . . .	. . . . .	. . . . .		Irregular	–	–	
5928	–	1860 Apr. 6	240 0507	+361 E ?		Present epoch in doubt	5	–	1860. 69–74, 83
5931	–	1857 June 29	239 9495	+233.8 E			8	–	1857–71, 89–91
5948	–	. . . . . .	. . . . .	. . . . .		Irregularly periodic	–	–	
5949	–	. . . . . .	. . . . .	$4^{\mathrm{d}}\ 10^{\mathrm{h}}\ 12^{\mathrm{m}}.7$		(Roberts) *Algol*-type	–		
5950	125	1879 July 12	240 7543	+280.0 E	+25 sin (15° E+330°)		15	5	1857, 79–95
5952		. . . . . .	. . . . .	20.5			–	–	
5955	112	1877 Apr. 5	240 6715.8	+245.6 E			20	6	1797, 1858, 77–96
6005	–	. . . . . .	. . . . .	. . . . .			–	–	
6044	148	1856 Sept. 9	239 9202	+308.1 E		Large irregularities	24	10	1840–95

No.	Star	1900,0		1900 Annual Variation		1855.0		Red-ness	Magnitude	
		R.A.	Decl.			R.A.	Decl.		Max.	Min.
		h m s	° ′	s	′	h m s	° ′			
6050	RS Scorpii	16 48 22	−44 56.3	+4.34	−0.10	16 45 7	−44 51.6	–	7.0	11.4
6062	RR Scorpii	50 15	−30 25.3	3.82	0.10	47 23	−30 20.7	–	6.8– 7.7	9.3–10.0
6071	RV Scorpii	51 47	−33 27.2	3.92	0.10	48 51	−33 22.7	6	6.8	7.6
6083	— Ophiuchi	53 54	−12 44.4	3.36	0.10	51 23	−12 40.0	5	5.5	12.5
6101	RT Scorpii	16 56 48	−36 40	4.03	0.09	53 47	−36 36	–	9.2	12.9<
6132	R Ophiuchi	17 2 1	−15 57.6	3.44	0.08	16 59 27	−15 53.7	4.5	7.0– 8.1	<12
6170	RW Scorpii	8 18	−33 19	3.93	0.07	17 5 21	−33 15	–	9.4	14.1
6181	α Herculis	10 5	+14 30.2	2.73	0.07	8 2	+14 33.5	5	3.1	3.9
6189	U Ophiuchi	11 27	+ 1 19.3	3.01	0.07	9 11	+ 1 22.6	0	6.0	6.7
6202	u Herculis	13 38	+33 12.3	2.21	0.07	11 58	+33 15.5	4	4.6	5.4
6207	Z Ophiuchi	14 28	+ 1 37.3	3.04	0.07	12 12	+ 1 40.3	3.0	7.5– 8.2	11.8–12.5
6225	RS Herculis	17 31	+23 1.1	2.51	0.06	15 38	+23 3.9	–	8.0	11
6268	— Serpentarii	21 38	−21 23.7	3.59	0.05	21 57	−21 21.2	–	>1	?
6275	S Octantis	25 54	−86 46	26.41	0.04	6 17	−86 43	–	8.2	<11.7
6331	RU Scorpii	35 6	−43 42	4.34	0.04	31 51	−43 40	-	9.3	12.7
6368	X Sagittarii	41 16	−27 47.6	3.77	0.03	38 26	−27 46.2	1	4	6
6404	Y Ophiuchi	47 17	− 6 7.1	3.22	0.02	44 52	− 6 6.2	–	6.2	7.0
6442	Z Herculis	53 36	+15 8.8	2.71	0.01	51 34	+15 9.3	–	7.1	8.0
6449	T Draconis	54 51	+58 13.6	0.90	0.01	54 11	+58 14.0	–	8.2	11.7
6472	W Sagittarii	17 58 38	−29 35.1	3.83	0.00	55 45	−29 34.9	1	4.8	5.8
6500	R Pavonis	18 3 17	−63 38.1	5.77	0.00	17 58 57	−63 38.2	–	7.5	9.8
6512	T Herculis	5 19	+31 0.2	2.27	+0.01	18 3 37	+30 59.9	1.4	6.9– 8.5	9.8–12.7
6546	RS Sagittarii	10 59	−34 8.5	3.98	0.01	8 0	−34 9.1	–	6.4	7.5
6573	Y Sagittarii	15 30	−18 54.3	3.53	0.02	12 51	−18 55.2	0	5.8	6.6
6608	RV Sagittarii	21 21	−33 22.9	3.95	0.03	18 24	−33 24.2	–	8.2	12.3
6613	d Serpentis	22 6	+ 0 8.2	3.07	0.03	19 48	+ 0 6.8	–	5.0	5.7
6624	T Serpentis	23 56	+ 6 14.0	2.93	0.03	21 44	+ 6 12.5	2.0	9.1–10.5	<13.5
6636	U Sagittarii	26 0	−19 11.7	3.54	0.04	23 21	−19 13.3	3.7	7.0	8.3
6653	T Lyrae	28 54	+36 55.0	2.10	0.04	27 19	+36 53.1	–	7.2	7.8
6682	X Ophiuchi	33 35	+ 8 44.4	2.87	0.05	31 26	+ 8 42.3	5	6.8– 7.0	9.0
6726	T Aquilae	40 56	+ 8 38.3	2.87	0.06	38 47	+ 8 35.7	3.3	8.8	10.0
6733	R Scuti	42 9	− 5 48.7	3.21	0.06	39 45	− 5 51.4	4	4.7– 5.7	6.0– 9.0
6758	β Lyrae	46 23	+33 14.8	2.21	0.07	44 44	+33 11.8	1	3.4	4.5
6760	κ Pavonis	46 38	−67 21.5	6.21	0.07	41 58	−67 24.4	–	4.0	5.5
6794	R Lyrae	52 17	+43 48.8	1.82	0.08	50 55	+43 45.5	4	4.0	4.7
6806	S Coronae Austr.	54 26	−37 5.3	4.06	0.08	51 22	−37 8.6	–	>9.5	13
6811	R Coronae Austr.	55 9	−37 5.6	4.06	0.08	52 8	−37 8.8	–	9.8–11.5	13.2
6812	T Coronae Austr.	55 14	−37 6.4	4.06	0.08	52 12	−37 9	–	>9.8	13
6834	V Aquilae	18 59 4	− 5 50.0	3.21	0.09	56 40	− 5 53.7	6.3*	6.5	8.0
6849	R Aquilae	19 1 33	+ 8 4.8	2.89	0.09	18 59 23	+ 8 0.8	5.5	5.9– 7.4	10.9–11.5
6854	Y Aquilae	2 16	+10 55.0	2.82	0.09	19 0 9	+10 51.0	–	5.3	5.7
6874	V Lyrae	5 9	+29 30.0	2.35	0.09	3 24	+29 25.8	–	9.1	<12
6888	RW Sagittarii	8 4	−19 1.8	3.51	0.09	5 26	−19 6.2	–	9.7	11.1
6892	RX Sagittarii	8 42	−18 58.8	3.51	0.09	6 4	−19 3.2	–	9.9	<13.3
6894	S Lyrae	9 6	+25 50	2.45	0.10	7 16	+25 45.6	–	9.0	12.0
6900	W Aquilae	10 0	− 7 13.2	3.23	0.10	7 34	− 7 17.6	7	7.5	11.2
6903	T Sagittarii	10 28	−17 8.7	3.47	0.10	7 52	−17 13.2	6.5	7.6– 8.1	<11
6905	R Sagittarii	10 49	−19 29.0	3.52	0.10	8 11	−19 33.5	3.6	7.0– 8.0	12.5
6921	S Sagittarii	19 13 35	−19 12.4	+3.51	+0.11	19 10 57	−19 17.1	0	9.1–10.4	14.5

No.	$M-m$	Elements of Maximum, Greenwich M.T.					Basis of Elements		
		Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	M	m	Dates included
6050	–	1889 June 9	241 1163^d	+307^d E ?			6	–	1873–80, 89–94
6062	125:	1887 June 23	241 0446	+282 E			5	1	1846, 87–95
6071	2	. . . .		6.45	(Roberts)		–	–	
6083	–	. . . .		. . . . .	New star of 1848		–	–	
6101	–	. . . .		. . . . .			–	–	
6132	–	1857 July 11	239 9507	+302.7 E			10	–	1847, 57–72, 84–95
6170	–	1890 Feb. 1	241 1412	+387 E ?			4	–	1890–95
6181	–	. . . .		. . . . .	Irregular			–	
6489	–	Min. 1881 July $17^d\ 14^h\ 45^m$		$+20^h\ 7^m\ 42^s.56$ E	$+80^m$ sin (0°.0225 E+140°.0)		–	98	1863, 71, 84–92
6202	–	. . . .		. . . . .	Irregularly periodic		–	–	
6207	165:	1893 May 6	241 2590	+348 E			3	2	1893–95
6225	–	. . . .		. . . . .			–	–	
6268	–	. . . .		. . . . .	New star of 1604		–	–	
6275	–	. . . .		. . . . .			–	–	
6331	–	1889 Aug. 4	241 1219	+380 E ?			4	–	1889–94
6368	2.876	1870 Aug. 16	240 4291.78	+ 7.01185 E			400	375	1866–94
6404	6.22	1882 Sept. 5	240 8694.25	+ 17.1207 E			52	53	1882, 86–94
6442	–	Min. 1894 July $28^d\ 11^h\ 8^m.2$		$+3^d\ 23^h\ 49^m.545$ E		*Algol*-type. *	–	–	
6449	–	1894 Dec. 27	241 3190	+569 E	(Hartwig)		2	1	1894–95
6472	3.00	1866 Sept. 4	240 2849.45	+ 7.59460 E			–	–	
6500	–	. . . .		. . . . .			–	–	
6512	78	1868 Mar. 9	240 3401.0	+164.85 E	+8 sin (7° E+59°)		40	29	1856–95
6546	–	Min. 1871 Sept. $5^d\ 16^h\ 0^m$		$+2^d\ 9^h\ 58^m.6$ E		*Algol*-type	–	13	1871, 72, 95
6573	1.8	1886 Sept. 25	241 0175.02	+ 5.7732 E			69	81	1882, 86–94
6608	–	1889 July 31	241 1215	+316 E	(Pickering)		5	–	1889–95
6613	–	. . . .		8.72	(Yendell)		–	–	
6624	–	1861 May 11	240 0907.0	+342.3 E			15	–	1861–74, 83–89
6636	2.97	1870 July 1	240 4245.0	+ 6.7446 E			–	–	1866–95
6653	–	. . . .		. . . . .			–	–	
6682	–	1886 June 3	241 0061	+335 E			5	3	1854, 86–95
6726	–	. . . .		. . . . .	Irregular		–	–	
6733	–	. . . .		71.1	Large irregularities		–	–	
6758	–	Min. 1855 Jan. $6^d\ 15^h.0$		$+12^d\ 21^h\ 47^m\ 23^s.72$ E	$+0^s.315938\ E^2$ †		–	–	
6760	4.0	1871 Dec. 3	240 4765	+ 9.102 E			5	3	1871–73, 83, 91
6794	22.7	1887 Oct. 14	241 0559.3	+ 46.4 E			22	24	1887–94
6806	–	. . . .		. . . . .			–	–	
6811	–	. . . .		30.6			–	–	
6812	–	. . . .		. . . . .			–	–	
6834	–	. . . .		. . . . .	Irregular		–	–	
6849	144	1856 Aug. 5	239 9167	+350.6 E	$-0.32\ E^2$		19	5	1854–59, 69–94
6854	–	1894 Aug. 6	241 3047.7	+ 4.986 E			–	–	
6871	–	1893 Aug. 24	241 2700	+377 E ?			3	–	1893–95
6888	–	. . . .		. . . . .			–	–	
6892	–	. . . .		. . . . .			–	–	
6894	–	1893 July 15	241 2660	+430 E ?			3	–	1893–95
6900	–	1893 July 1	241 2646	+490 E ?			2	–	1893, 94
6903	–	1895 July 9	241 3384	+384 E			8	–	1865–95
6905	145	1866 July 18	240 2801	+268.7 E	+20 sin (10° E+330°)		16	2	1849, 58–74, 84–94
6921	110:	1866 Sept. 25	240 2870	+230.6 E	Periodic inequality		13	1	1863–71, 83–95

* Sec. min. 45^h later. (Hartwig)

† $-0^s.00001211\ E^3$. (Schur) Secondary minimum midway

No.	Star	1900.0		1900 Annual Variation		1855.0		Red-ness	Magnitude	
		R.A.	Decl.			R.A.	Decl.		Max.	Min.
		h m s	° '	s	'	h m s	° '			
6923	Z Sagittarii	19 13 47	−21 6.6	+3.56	+0.11	19 11 7	−21 11.2	2	8.5	<12
6940	U Lyrae	16 37	+37 41.7	2.10	0.12	15 3	+37 36.6	–	8.3	<11
6943	T Sagittae	17 14	+17 28.1	2.68	0.11	15 13	+17 23.2	5.5*	8.3– 8.7	9.4– 9.9
6984	U Aquilae	23 58	− 7 15.0	3.23	0.12	21 33	− 7 20.3	0	6.4	7.1
7045	R Cygni	34 8	+49 58.5	1.61	0.13	32 56	+49 52.5	6.0	5.9– 8.0	<14
7077	T Pavonis	39 31	−72 0.7	6.81	0.14	34 22	−72 6.9	–	7.6	12.1
7085	RT Cygni	40 50	+48 31.9	1.70	0.14	39 33	+48 25.5	3.8*	7.0– 7.5	10.0–11.15
7101	11 Vulpeculae	43 28	+27 1.2	2.46	0.15	41 37	+26 57.7	–	3	?
7106	S Vulpeculae	44 18	+27 2.3	2.46	0.15	42 27	+26 55.7	3.0	8.4– 8.9	9.0–10.0
7118	X Aquilae	46 31	+ 4 12.5	2.98	0.15	44 17	+ 4 5.9	–	8.4– 8.8	<12
7120	χ Cygni	46 44	+32 39.7	2.31	0.15	45 0	+32 33.0	6.5	4.0– 6.5	13.5
7122	S Pavonis	46 47	−59 27.2	5.10	0.15	42 57	−59 33.9	–	8.0	9.6
7124	η Aquilae	47 23	+ 0 44.9	3.06	0.15	45 5	+ 0 38.2	2	3.5	4.7
7139	RR Sagittarii	49 43	−29 27.2	3.74	0.15	46 54	−29 34.0	–	7.5	<12.5
7149	S Sagittae	51 29	+16 22.2	2.73	0.16	49 25	+16 15.4	0	5.6	6.4
7151	RU Sagittarii	51 50	−42 6.9	4.14	0.16	48 14	−42 13.9	–	8	<12.6
7155	RR Aquilae	52 24	− 2 11	3.12	0.16	50 6	− 2 18	6	8.4	<12
7162	RS Aquilae	53 12	− 8 10	3.21	0.16	51 16	− 8 17	–	10.0	<12.4
7192	Z Cygni	19 58 38	+49 45.9	1.70	0.17	19 57 21	+49 38.4	9.0*	7.1– 8.5	11.5–12
7220	S Cygni	20 3 24	+57 41.9	1.26	0.17	20 2 28	+57 34.2	5.1	8.8–11.3	<14.5
7234	R Capricorni	5 12	−14 33.8	3.37	0.17	3 10	−14 41.6	4	8.8–10.8	<13
7240	RY Cygni	6 37	+35 38.8	2.26	0.18	4 55	+35 31.0	–	8.5	9.5
7242	S Aquilae	7 1	+15 19.4	2.76	0.18	4 57	+15 11.5	0.8	8.4–10.1	10.7–11.8
7245	R Telescopii	7 42	−47 18	4.30	0.18	4 28	−47 26	–	8.4	11.6
7247	RX Cygni	7 46	+47 30.9	1.84	0.18	6 24	+47 23.0	–	7.5	8.3
7252	W Capricorni	8 36	−22 16.8	3.54	0.18	5 57	−22 24.8	–	10.2–11.0	<14.7
7257	R Sagittae	9 30	+16 25.4	2.74	0.18	7 27	+16 17.4	0.8	8.5– 8.7	9.8–10.4
7259	RS Cygni	9 45	+38 27.8	2.18	0.18	8 7	+38 17.4	9.4*	6–8	8.3–10
7260	Z Aquilae	9 51	− 6 27.4	3.20	0.18	7 27	− 6 35.4	–	8.8– 9.0	11?
7261	R Delphini	10 5	+ 8 47.1	2.90	0.18	7 55	+ 8 39.1	1.0	7.6– 9.0	11.1–12.8
7266	RT Sagittarii	11 6	−39 25.2	4.01	0.18	8 5	−39 33.3	–	7.5	<11.0
7285	P Cygni	11 6	+37 43.3	2.21	0.18	12 27	+37 35.1	2	3.5	<6
7299	U Cygni	16 30	+47 34.7	1.86	0.19	15 7	+47 26.3	9.3	7.0– 8.1	9.4–11.6
7351	RW Cygni	25 12	+39 38.8	2.18	0.20	23 34	+39 29.9	7.0*	7.7	10.5
7399	W Delphini	33 7	+17 55.9	2.73	0.21	31 4	+17 46.6	–	9.5	<12
7404	R Microscopii	33 58	−29 8.6	3.65	0.20	31 13	−29 17.9	–	8.0	12.0
7428	V Cygni	38 5	+47 47.1	1.93	0.21	36 28	+47 37.5	8.3	6.8– 9.5	13.5
7434	S Delphini	38 28	+16 13.7	2.76	0.21	36 24	+16 34.2	6.0	8.4– 9.5	10.4–12.0
7435	Y Aquarii	39 9	− 5 12.0	3.17	0.21	36 16	− 5 21.6	–	8.8	<13
7437	X Cygni	39 29	+35 13.6	2.35	0.21	37 44	+35 4.0	0	6.4	7.2– 7.7
7444	T Delphini	40 43	+16 2.1	2.78	0.22	38 38	+15 52.5	2.0	8.2–10.3	<13
7446	U Delphini	40 53	+17 43.7	2.75	0.22	38 50	+17 34.0	7	6.4	7.3
7448	W Aquarii	41 10	− 4 26.9	3.15	0.22	38 48	− 4 36.6	–	8.0	9.6?
7450	V Aquarii	41 46	+ 2 4.2	3.04	0.22	39 29	+ 1 54.6	2.5*	8.1	9.3
7455	U Capricorni	42 34	−15 9.1	3.35	0.22	40 4	−15 18.8	–	10.2–10.8	<13
7456	RR Cygni	42 37	+44 30.2	2.07	0.22	41 3	+44 20.4	6.7*	8.1– 8.7	9.3– 9.7
7458	V Delphini	43 14	+18 58.0	2.72	0.22	41 11	+18 48.3	–	8.9– 9.1	12 ?
7459	T Cygni	43 14	+34 0.4	2.39	0.22	41 24	+33 50.6	1	5.5 ?	6 ?
7468	T Aquarii	20 44 10	− 5 31.1	+3.17	+0.22	20 42 17	− 5 40.9	1.2	6.7– 8.7	12.4–13.0

No.	$M-m$	Elements of Maximum, Greenwich M.T.					Basis of Elements		
		Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	M	m	Dates included
6923	–	1888 Aug. 15	241 0865^d	+452^d E			3	–	1888–94
6940	–	. . . .	. . . . .	. . . .			–	–	
6943	50:	1885 Dec. 31	240 9907	+165 E ?			4	6	1855, 56, 85–94
6984	2.18	1886 Sept. 20	241 0170.15	+ 7.0240 E			105	87	1886–94
7045	150	1854 Oct. 16	239 8508.9	+425.7 E			27	7	1847, 52–95
7077	–	1889 May 5	241 1128	+243 E		(Pickering)	5	–	1889–95
7085	88	1887 Aug. 24	241 0508	+191.4 E			11	7	1842, 77, 87–96
7101	–	. . . .	. . . . .	. . . .		New star of 1670	–	–	
7106	26.5	1865 Jan. 2	240 2239.0	+ 67.5 E		Periodic inequality	50	46	1836, 37, 62–93
7118	–	1893 Aug. 14	241 2690	+348 E			4	–	1854, 93–95
7120	171.5	1763 June 3	236 5136.5	+406.02 E	+0.0075 E^2 +25 sin(5° E+272°)		88	9	1687–1894
7122	–	. . . .	. . . . .	. . . .			–	–	
7124	2.25	1848 May 20	239 6168.6253	+7.176381 E		(Schur)	–	–	
7139	140:	1891 Sept. 26	241 2002	+338 E			3	4	1879, 89–92
7149	3.40	1876 Dec. 13	240 6602.60	+ 8.38320 E			81	79	1876–94
7151	–	. . . .	. . . . .	. . . .			–	–	
7155	–	1895 July 1	241 3376	+403 E ?			3	–	1888–95
7162	–	. . . .	. . . . .	. . . .			–	–	
7192	125:	1887 Mar. 11	241 0342	+265 E			9	4	1887–95
7220	150:	1865 June 29	240 2417	+322.8 E	+15 sin (12° E+66°)		32	2	1841, 60–95
7234	–	1859 Dec. 12	240 0391	+345 E ?			5	–	1859–68
7240	–	. . . .	. . . . .	. . . .			–	–	
7242	72	1865 Nov. 12	240 2553	+146.7 E			27	26	1855–91
7245	–	. . . .	. . . . .	. . . .			–	–	
7247	–	. . . .	. . . . .	. . . .		Irregular ?	–	–	
7252	87:	1872 July 10	240 4985	+207.7 E			11	1	1872–95
7257	16.0	1859 Nov. 12	240 0361.0	+70.52 E	+5 sin (2°.5 E+55°)*		133	54	1859–92
7259	–	. . . .	. . . . .	. . . .		Irregularly periodic ?	–	–	
7260	–	1894 Oct. 15	241 3117	+130 E ?		(Holetschek)	5	–	1876, 79, 94, 95
7261	150:	1865 Aug. 26	240 2475	+285.5 E		Periodic inequality ?	12	1	1851, 59–83, 93, 94
7266	–	1895 July 5	241 3380	+311 E		(Paul)	–	–	
7285	–	. . . .	. . . . .	. . . .		So-called new star of 1600	–	–	
7299	229.0	1871 June 7	240 4586	+463.5 E	+12 sin (36° E+324°)		16	16	1871–94
7351	–	. . . .	. . . . .	. . . .			–	–	
7399	–	Min. 1896 Jan. $5^d\ 13^h.7$		$+4^d\ 19^h\ 21^m.2$ E		(Pickering) *Algol*-type	–	–	
7404	64	1895 Nov. 12	241 3510.6	+138.8 E		(Paul)	3	–	1889–95
7428	220	1881 June 12	240 8244	+418 E			9	2	1857, 81–94
7431	118	1866 Jan. 19	240 2621	+277.5 E			15	11	1863–95
7435	–	. . . .	. . . . .	. . . .			–	–	
7437	6.8	1886 Oct. 10	241 0190.90	+ 16.3855 E			112	109	1886–95
7444	–	1864 Sept. 16	240 2133	+331.2 E			17	–	1855–93
7446	–	. . . .	. . . . .	. . . .		Irregular ?	–	–	
7448	180:	1888 Oct. 14	241 0925	+381 E			4	1	1888–95
7450	–	1891 Jan. 27	241 1760	+240 E			4	2	1891–95
7455	–	1857 Sept. 15	239 9573.5	+202.5 E	+20 sin (5° E+285°)		13	–	1852–59, 72–95
7456	–	1888 May 8	241 0766	+165 E ?			5	1	1888–94
7458	–	1890 Dec. 20	241 1722	+540 E			2	–	1890–93
7459	–	. . . .	. . . . .	. . . .			–	–	
7468	88	1861 Nov. 16	240 1096.0	+203.3 E	+8 sin (7°.5 E+255°)		22	5	1794, 1865–95

* Secondary maximum midway

No.	Star	1900.0 R.A.	1900.0 Decl.	1900 Annual Variation		1855.0 R.A.	1855.0 Decl.	Redness	Magnitude Max.	Magnitude Min.
		h m s	° ′	s	′	h m s	° ′			
7182	U Pavonis	20 17 10	−63 5.2	+5.08	+0.22	20 43 23	−63 15.1	–	9.6	<12.3
7183	T Vulpeculae	17 13	+27 52.5	2.55	0.22	45 19	+27 42.3	0	5.5	6.5
7188	V Cygni	18 1	+34 17.0	2.10	0.22	46 16	+34 7.0	0	7.1	7.9
7192	RZ Cygni	18 28	+46 58.8	2.01	0.22	46 57	+46 48.8	–	9.1	13
7195	S Indi	18 59	−54 42.3	4.17	0.22	45 37	−54 52	–	8.4	<12.4
7502	X Delphini	50 17	+17 14.3	2.77	0.23	48 13	+17 4.2	–	8.0	<10
7544	T Octantis	57 24	−82 30	10.33	0.23	49 30	−82 40	–	9.0	<12.5
7560	R Vulpeculae	20 59 56	+23 25.5	2.66	0.24	57 56	+23 14.9	2.0	7.5– 8.5	12.5–13.6
7571	V Capricorni	21 1 17	−24 19.3	3.50	0.24	20 59 9	−24 30.2	–	9	14?
7577	X Capricorni	2 50	−21 45.1	3.44	0.24	21 0 15	−21 55.8	–	9.5–10.5	<16.2
7590	Z Capricorni	5 3	−16 35.2	3.35	0.24	2 32	−16 46.0	–	9.0	11.5
7609	T Cephei	8 13	+68 5.0	0.81	0.24	7 33	+67 54.4	6.3	5.2– 6.8	8.6–10.7
7659	T Capricorni	16 30	−15 35.0	3.32	0.25	14 0	−15 46.4	2	8.8– 9.7	13.5
7733	Y Capricorni	28 55	−14 25.1	3.28	0.26	26 27	−14 36.9	–	10–11	14?
7754	W Cygni	32 14	+44 55.6	+2.27	0.27	30 34	+44 43.7	4.2*	5.0– 6.3	6.1– 6.7
7779	S Cephei	36 28	+78 10.3	−0.67	0.27	36 57	+77 58.2	9.1	7.4– 9.2	11.5–12.3
7783	RU Cygni	37 19	+53 52.2	+2.00	0.27	35 46	+53 40.0	–	7.5	9.2
7787	Q Cygni	37 47	+42 23.1	2.36	0.27	36 1	+42 11.0	3	3	14.8
7795	RV Cygni	39 8	+37 33.6	2.48	0.27	37 18	+37 21.2	9.0*	7.1– 7.8	8.8– 9.3
7803	μ Cephei	40 27	+58 19.3	1.83	0.27	39 4	+58 7.0	6.2	4 ?	5?
7813	R Gruis	42 6	−47 22	3.89	0.28	39 10	−47 34	–	8.4	<12.5
7896	V Pegasi	56 2	+ 5 38.4	3.00	0.28	53 47	+ 5 25.6	–	8.2	<13
7907	U Aquarii	57 52	−17 6.5	3.28	0.29	55 24	−17 19.5	–	9.5–10	14?
7909	S Piscis austrini	21 58 2	−28 32.0	3.41	0.29	21 55 27	−28 44.9	–	8.7– 9.2	<11
7941	T Pegasi	22 4 1	+12 3.0	2.93	0.29	22 1 49	+11 49.9	3	8.5– 9.3	<13
7994	R Piscis austrini	12 19	−30 6.2	3.42	0.30	9 45	−30 19.6	–	8.5	<11?
7999	X Aquarii	13 9	−21 24.0	3.31	0.30	10 40	−21 37.4	–	8.3	13
8039	T Gruis	19 51	−38 4.5	3.52	0.30	17 13	−38 18.0	–	8.6	11.0
8040	S Gruis	19 55	−48 56.8	3.72	0.30	17 7	−49 10.4	–	7.2	12.3
8068	S Lacertae	24 38	+39 48.2	2.62	0.31	22 40	+39 34.3	–	7.6– 8.2	<12
8073	δ Cephei	25 27	+57 54.2	2.22	0.31	23 48	+57 40.4	2	3.7	4.9
8093	R Indi	28 53	−67 48.3	4.34	0.31	25 36	−68 2.4	–	9 ?	11?
8116	W Cephei	32 39	+57 54.4	2.28	0.31	30 56	+57 40.5	4.5*	7.3	8.3
8153	R Lacertae	38 50	+41 50.9	2.66	0.31	36 50	+41 36.8	1.8	8.3– 9.3	<13.5
8230	S Aquarii	51 45	−20 52.6	3.22	0.32	49 20	−21 7.0	4.0	7.7– 9.1	<12.5
8273	β Pegasi	22 58 55	+27 32.4	2.90	0.32	56 45	+27 17.8	2	2.2	2.7
8290	R Pegasi	23 1 38	+10 0.2	3.01	0.32	22 59 22	+ 9 45.7	4	6.9– 7.9	<13
8324	V Cassiopeae	7 22	+59 8.4	2.56	0.33	23 5 27	+58 53.8	–	7.1– 8.0	12.4
8369	W Pegasi	14 16	+25 43.5	2.95	0.33	12 34	+25 29.1	–	8.1	10
8373	S Pegasi	15 29	+ 8 22.3	3.03	0.33	13 13	+ 8 7.6	1.7	7.3– 8.0	12–<13
8512	R Aquarii	38 39	−15 50.3	3.11	0.35	36 19	−16 5.3	4.3	5.8– 8.5	11?
8588	R Phoenicis	51 16	−50 20.6	3.13	0.33	48 55	−50 35.6	–	8.5 ?	11?
8591	V Cephei	51 44	+82 38.1	2.70	0.33	49 44	+82 23.0	–	6.2– 6.4	6.8– 7.1
8594	R Tucanae	52 12	−65 56	3.17	0.33	49 48	−66 11	–	10.2	<12.6
8597	V Ceti	52 17	− 9 31.1	3.08	0.33	50 29	− 9 46.1	-	8.5– 9.5	14?
8598.	U Pegasi	52 53	+15 23.9	3.06	0.33	50 35	+15 8.9	0	9.0	9.7
8600	R Cassiopeae	53 19	+50 49.9	3.02	0.33	51 4	+50 34.9	6.5	4.8– 7.0	9.7–12
8604	S Phoenicis	53 54	−57 7.7	3.15	0.33	51 33	−57 22.9	–	7.2	8.7
8622	W Ceti	23 57 0	−15 13.9	+3.08	+0.33	23 54 11	−15 29.0	–	8.4	12.0

No.	$M-m$	Elements of Maximum, Greenwich M.T.					Basis of Elements		
		Epoch (Cal.)	(Julian)	Period	Inequalities	Remarks	M	m	Dates included
7482	–	1891 July 10	$241\,1924^{\mathrm{d}}$	$+290^{\mathrm{d}}$ E ?			4	–	1891–95
7483	1.40	1885 Nov. 2	240 9848.95	+ 4.4360 E			222	222	1885–95
7488	–	Min. Even 1886 Dec. $9^{\mathrm{d}}\,11^{\mathrm{h}}\,10^{\mathrm{m}}.8$ Min. Odd 1886 " $9^{\mathrm{d}}\,9^{\mathrm{h}}\,57^{\mathrm{m}}.0$		$+1^{\mathrm{d}}\,11^{\mathrm{h}}\,57^{\mathrm{m}}\,27^{\mathrm{s}}.6$ E $+1^{\mathrm{d}}\,11^{\mathrm{h}}\,57^{\mathrm{m}}\,15^{\mathrm{s}}.2$ E		(Dunér)	–	91	1886–93
7492	–	. . . .		. . . . .			–	–	
7495	–	. . . .		. . . . .			–	–	
7502	–	. . . .		. . . . .			–	–	
7544	–	. . . .		. . . . .			–	–	
7560	62.0	1865 Sept. 18	240 2498.0	+136.90 E	+18 sin (4° E+80°)		30	11	1807, 10, 59–95
7571	–	1867 Aug. 18	240 3197	+157.1 E	+15 sin (10° E+100°)		12	–	1867, 78–94
7577	117:	1867 Aug. 17	240 3196	+218.1 E	+20 sin (10° E+50°)		11	1	1867, 76–95
7590	–	1895 Nov. 28	241 3526	+392 E ?			3	–	1876, 94, 95
7609	200	1873 July 19	240 5359	+387 E			15	10	1789, 1873–94
7659	149	1855 Oct. 21	239 8878	+269.2 E			15	2	1850–72, 83–94
7733	–	1885 Sept. 5	240 9790	+206 E			6	–	1871, 85, 95
7754	70.0	1884 Nov. 25	240 9506	+131.5 E			26	23	1885–94
7779	257	1865 June 21	240 2409	+484 E			12	5	1789, 1841–93
7783	–	1890 May 6	241 1484	+396 E			5	1	1890–94
7787	–	. . . .		. . . . .		New star of 1876	–	–	
7795	–	. . . .		. . . . .		Irregular			
7803	–	. . . .		. . . . .		Irregularly periodic	–	–	
7813	–	1892 Oct. 4	241 2376	+350 E ?			3	–	1892–94
7896	–	. . . .		. . . . .			–	–	
7907	–	1875 Aug. 4	240 6105	+258 E ?			10	–	1875–93
7909	–	1890 Sept. 9	241 1620	+272 E		(Holetschek)	3	–	1890–95
7944	–	1864 Oct. 6	240 2151	+373 E		Periodic inequality	14	–	1822, 54–83
7994	–	1872 Oct. 19	240 5086	+292 E ?			4	–	1872, 85, 92, 95
7999	–	1895 June 20	241 3365	+311 E		(Paul)	–	–	
8039	–	. . . .		. . . . .			–	–	
8040	–	1889 Oct. 14	241 1290	+400 E		(Pickering)	3	–	1889–95
8068	113	1891 July 16	241 1930	+233 E			5	4	1889–96
8073	$1^{\mathrm{d}}\,14^{\mathrm{h}}.6$	1840 Sept. $26^{\mathrm{d}}\,10^{\mathrm{h}}\,50^{\mathrm{m}}$		$+5^{\mathrm{d}}\,8^{\mathrm{h}}\,47^{\mathrm{m}}\,39^{\mathrm{s}}.3$ E	$-0.0008\,E^2-0.000\,000\,15_6E^3$		289	278	1785–1889
8093	–	. . . .		. . . . .			–	–	
8116	–	. . . .		. . . . .		Short period, or irregular	–	–	
8153	–	1883 Feb. 15	240 8857	+299.8 E			9	–	1856, 83–94
8230	–	1859 Dec. 16	240 0395	+279.7 E		Periodic inequality	16	–	1798, 1853–95
8273	–	. . . .		. . . . .		Irregular	–	–	
8290	172:	1850 Dec. 26	239 7118	+380.0 E	+30 sin (10° E+200°)		20	5	1841–55, 66–94
8324	105	1893 Nov. 28	241 2796	+229 E			5	4	1857, 93–96
8369	–	. . . .		. . . . .			–	–	
8373	143:	1864 Dec. 4	240 2210.5	+317.5 E			7	3	1864–95
8512	–	1811 Nov. 30	238 2847.6	+387.16 E	+35 sin (10° E+235°)		23	1	1811–86, 94
8588	–	. . . .		. . . . .			–	–	
8591	220	1883 Mar. 16	240 8886	+360 E			6	8	1882, 83, 90–95
8594	–	. . . .		. . . . .			–	–	
8597	–	1879 Aug. 28	240 7590	+261 E			8	–	1879–93
8598	$3^{\mathrm{h}}\,4^{\mathrm{m}}$	1894 Sept. $22^{\mathrm{d}}\,19^{\mathrm{h}}\,45^{\mathrm{m}}.3$		$+5^{\mathrm{h}}\,32^{\mathrm{m}}\,15^{\mathrm{s}}$ E			15	7	1894, 95
8600	188	1854 July 4	239 8404	+429.5 E	+25 sin (15° E+0°)		28	9	1850–95
8604	–	. . . .		. . . . .			–	–	
8622	–	1896 Feb. 10	241 3600	+350 E		(Paul)	–	–	1895, 96

NOTES TO THE CATALOGUE.

The following notes, like those appended to the Second Catalogue, pertain to the facts with regard to the discovery and confirmation of the variability of the several stars, and to other data of a miscellaneous useful nature.

In the case of the stars found at the Harvard College Observatory, the discoverer is Mrs. Fleming, except where otherwise noted. Prof. Pickering has stated that all of these have been verified by him before their announcement. This was presumably done by means of the same photographs. I have excluded a few of these stars, however, in which the observed range is apparently not sufficiently beyond the possible effect of mere observational errors. Where there has been independent outside confirmation, the facts are stated.

I trust to be pardoned in remarking that it has been a constant endeavor, both in this Catalogue and in the former editions and their Supplements, to be punctiliously fair in apportioning credit in regard to the various discoveries and confirmations, and to make the necessary brevity consistent with strict historical accuracy of statement. Any criticisms made in this regard should not be accepted as justified, without an independent searching examination of the facts.

22. Disc. at H C.O., 1895.

62. Disc. at H.C.O., 1894; conf. by Hartwig and Markwick. Period may be 366$^{\rm d}$.

100. Disc. by Chandler, 1881; conf. by Sawyer. Occasionally rudely periodic, 60–70$^{\rm d}$, at other times irregular.

103. Disc. by Anderson, 1893; conf. by Hartwig. Pickering thinks period is 281$^{\rm d}$.

107. Disc. by Krueger, 1870. Light-curve flat at max., with sometimes a sec. min. near this phase. 8$^{\rm M}$ foll. 10$^{\rm s}$, 0′.5 N.

110. Disc. at H.C.O., 1895.

112. Disc. at Bonn, 1858. Sometimes has sec. phases following principal max. one or two mos. 12$^{\rm M}$ pr. 3$^{\rm s}$, 2′ S; 9$^{\rm M}$ pr. 31$^{\rm s}$ on parallel.

114. Susp. by Borrelly, 1872; proved by Schönfeld. 12$^{\rm M}$ foll. 2$^{\rm s}$, 4′.5 S; 12$^{\rm M}$ pr. 3$^{\rm s}$, 6′ N.

116. Tycho's star. Probable place according to Argelander. Possibly identical with a 10$^{\rm M}$.5 now visible 0′.8 N.

146. Susp. by Thome, 1894; proved by West.

161. Disc. by Luther, 1855. Schönfeld's obsns. show irregular periods. 2½–5 mos.

209. Disc. by Birt, 1831; conf. by Sir J. Herschel and others. Var. only occasionally evident. Argelander found period 79$^{\rm d}$, uncertain.

224. Disc. by Hartwig, 1885. New star in *Andromeda* nebula.

243. Disc. by Espin, 1887; conf. by Chandler.

294. Disc. by Espin, (1888?) 1894; conf. by J. A. Parkhurst.

320. Disc. by Ceraski, 1880. *Algol*-type. Light-curve unusually flat at min., and unsymmetric; decrease more rapid than increase. Oscillations occupy one-sixth of period, or 10$^{\rm h}$; nearly stationary for 2$^{\rm h}$ at minimum. See investigations *A.J.* IX, 49 and XIII, 45. Elements of Second Catalogue retained.

401. Susp. by Thome, 1892; proved by West.

419. Disc. by Anderson, 1895; conf. by Copeland.

432. Disc. at Bonn, 1861. Light-curve variable. 9$^{\rm M}$.6 foll. 20$^{\rm s}$, 2′ S; 12$^{\rm M}$ pr. 15$^{\rm s}$, 0′.3 S.

434. Disc. by Hind, 1851. 11$^{\rm M}$.5 foll. 0$^{\rm s}$.5, 0′.7 N; 12$^{\rm M}$ directly S.

466. Disc. by Peters, 1880; conf. by H. M. Parkhurst. For stars of ident. see *A.N.* 99, 114.

494. Disc. by Gould, 1872; conf. by Sawyer.

513. Disc. by Hind, 1850. 11$^{\rm M}$ foll. 7$^{\rm s}$, 0′.5 N; 9$^{\rm M}$ pr. 9$^{\rm s}$, 4′ N.

659. Disc. by Espin, 1895; conf. by J. A. Parkhurst.

678. Disc. by Fleming, 1890; conf. by Yendell and Reed.

691. Found on H.C.O. photographs, 1887. Not since seen there or elsewhere.

715. Disc. by Peters, 1865. 9$^{\rm M}$.5 pr. 10$^{\rm s}$, 6′ S; 10$^{\rm M}$.5 foll. 5$^{\rm s}$, 4′.5 N.

782. Disc. at Bonn, 1857. Light-curve flat near max., 6$^{\rm M}$ pr. 23$^{\rm s}$, 0′.7 S.

793. Disc. by Safarik, 1882; conf. by Chandler and Schwarzschild. Either irregular or rudely periodic, with period of several months.

806. Disc. by Fabricius, 1596; recognized as periodically var. by Holwarda, 1638. Principal epoch of elements in catalogue corresponds to Ep. 227 of Argelander. Periodical terms given in Second Catalogue are here suppressed. Although they are undoubtedly real, complication with other unknown terms makes the accurate prediction of phases at present impossible. 9$^{\rm M}$.1 foll. 7$^{\rm s}$.7, 10″ N.

814. Disc. by Krueger, 1872. Probably irregular. Safarik and Hagen think it is rudely periodic, in long period, 2⅓ years. 10$^{\rm M}$ foll. 2$^{\rm s}$, 1′.1 N.

845. Disc. by Argelander, 1866. 11$^{\rm M}$ pr. 12$^{\rm s}$, 5′ N.

869. Susp. by Thome, 1891; proved by West.

893. Disc. by Sawyer, 1885; conf. by Chandler.

906. Susp. by Espin, 1890; proved by Yendell and Knott. Occasional secondary phases near maximum found by H. M. Parkhurst.

976. Disc. by Auwers, 1870. Light-curve very flat near max.

980. Disc. by Espin, 1893; conf. by Yendell, also by Hartwig who thinks period is 358$^{\rm d}$.

1018. Disc. at H.C.O., 1892; conf. by Roberts. I have assumed place to be 12^s foll., and 11′ south of that given by H.C.O., *A.N.* CXXX, 126.

1072. Disc. by Schmidt, 1854. Schmidt's period of $32^d.98$ not conf. by Schönfeld's obsns.

1090. Susp. by Montanari, 1669; independently disc. by Goodricke, 1782. Principal epoch of elements corresponds to Ep. 11210 of Argelander. See investigations, *A.J.* VII, 165–183; XI, 113–126. Light-oscillations occupy a little over 9^h.

1113. Disc. by Schaeberle, 1892; conf. by Glasenapp.

1166. Disc. at H.C.O., by Miss Wells, 1895.

1222. Disc. by Schönfeld, 1861. 12^M foll. 5^s, 0′.2 S; 12^M foll. 4^s, 1′.2 S; 12^M pr. 12^s, 0′.5 S.

1279. Susp. by Birmingham, 1871; independently announced at H.C.O., 1891. Observations, and conclusions as to actual variability, by various observers, Wendell, Yendell, Reed, Hartwig, for a long time mutually contradictory.

1357. Susp. by Thome, 1891; proved by West.

1367. Disc. by Gould, 1876; conf. by Chandler, also Yendell.

1386. Disc. at H.C.O., 1895; conf. by Paul.

1411. Disc. by Baxendell, 1848. Period certainly subject to inequalities, whose law it is not yet possible to determine. Deviations from uniform elements sometimes amount to 3^h. The light-oscillations occupy 10^h.

1537. Disc. by Hind, 1852; conf. by Auwers and Chacornac. Preceding the variable $1^s.8$, south 0′.4, is a nebula, disc. by Hind, 1852, supposed by D'Arrest to be itself variable; and later observations, by Lassell, Struve, Burnham and Barnard, seem to render this probable.

1574. Susp. by Espin, 1886; conf. by Gage, Chandler and H. M. Parkhurst. The doubt about its place has been cleared up by recent obsns. of Coit and J. A. Parkhurst.

1577. Disc. by Hind, 1849. 8^M pr. 15^s, 5′.5 S; 10^M foll. 3^s, 2′ N.

1582. Disc. by Oudemans, 1855. Townley thinks period is one-half of that in table. The small value of $M—m$ seems to favor this hypothesis, although there are no obsns. of max. to confirm it. $11^M.5$ foll. 9^s, 1′ S; $11^M.5$ foll. 4^s, 0′.7 S; 12^M pr. 6^s, 1′ N.

1623. Disc. by Espin, 1891; conf. by Dunér.

1635. Disc. by Ragoonathachari, 1867; conf. by Roberts.

1654. Disc. by Gould, 1874; conf. by Roberts. Period about 11 mos., by Roberts's obsns.

1662. Disc. at H.C.O., 1890; conf. by Roberts.

1701. Disc. at H.C.O., 1895.

1717. Disc. by Auwers, 1871. $12^M.5$ foll. 11^s, 1′ S; $11^M.5$ foll. 10^s, 3′.5 N.

1761. Disc. by Hind, 1848. 11^M foll. 11^s, 0′.3 N; 12^M pr. 7^s, 0′.6 S.

1768. Susp. by Fritsch, 1821; conf. by Schmidt, 1843; independently disc. by Heis, 1847. Variations irregular, often unnoticeable during many months.

1771. Disc. by Schmidt, 1855. Hind's "crimson star." Accurate obsns. of max. and min. difficult.

1800. Disc. at H. C. O., 1895, and independently by Sawyer.

1803. Disc. at H.C.O., 1895; conf. by Paul.

1805. Disc. by Boss, 1887; conf. by Yendell.

1850. Disc. at H.C.O., 1895.

1855. Disc. at Bonn, 1862. Schönfeld notes, and Chandler's obsns. confirm, the unusual phenomenon of a "stand-still" during increase at about 9^M, from 2 to 4 mos. before max. 9^M pr. 5^s, 0′.6 S.

1894. Disc. at H.C.O., 1896.

1923. Disc. by Dunér, 1881; conf. by Chandler. Period irregular; probably over 400^d, with secondary phases.

1944. Disc. by Webb, 1870; conf. by Schönfeld. Marked irregularities, and secondary phases in light-curve. 10^M about 1′ N; $9^M.5$ pr. $2^s.5$, 0′.4 S.

1953. Disc. by Anderson, 1892. A secondary max. occurred in Aug., 1892, $9^M.2$. No apparent change in 6 mos. preceding Apr., 1893, according to H. M. Parkhurst.

1981. Disc. by Espin, 1891; conf. by Yendell.

1986. Disc. by Bond, 1863. Schmidt's obsns. 1868–81, and Chandler's 1883–84, certainly confirm. While this is the only star in the nebula of *Orion* inserted in the Catalogue, there is little doubt that several others are variable. But the subject is a very intricate one, and requires especial investigation. Schmidt also found evidence of var. in B 746 and 784; but my careful watch of these in 1883–84, resulted in no certain confirmation of their variation. O. Stone has carefully observed the region for several years, and finds probable fluctuation in 575, 589, 622 and 647. He also confirms Holden's suspicions as to 641. Stone also finds that the relative brightness of 612 and 618, and of 671 and 676, seems to be variable. But he finds 675 invariable.

2013. Susp. by Espin, 1891; proved by Yendell. Elements consistent with DM. obsns., but numeration of periods not certain.

2059. Susp. by Thome, 1892; proved by West.

2080. Disc. by Hartwig in consequence of an announcement by H.C.O. (1893) of variability of a star foll. 32^s, 6′ south. Yendell confirms Hartwig's star, but the H.C.O. star has not been seen. Notwithstanding Pickering's verification of the south following star, it does not seem safe to accept its variability also, without further proof.

2098. Disc. by Sir J. Herschel, 1840. Argelander found period of 196^d. Schönfeld thought periodicity questionable.

2100. Disc. by Gore, 1885; generally confirmed. Elements from obsns. since 1885 will not satisfy various negative data, 1797–1857. This fact indicates existence of an inequality in the period, the mean value of which is probably about 371^d.

2141. Disc. at H.C.O., 1892. Place here adopted is $3^m\,12^s$ prec., and 1′ N of that given by H.C.O., (*A.N.* CXXX, 126).

2170. Disc. by Sawyer, 1891; conf. by Yendell.

2213. Disc. by Schmidt, 1865. Elements will satisfy Schmidt's min. of 1844, which Schönfeld's would not.

2258. Susp. by Espin, 1886; proved by Chandler, 1891; and Yendell, 1893. Hartwig finds a secondary maximum following principal one by 54^d.

2266. Disc. by Schönfeld, 1883; conf. by Chandler.

2279. Disc. by Gould, 1871. Elements in Catalogue are Yendell's.

2362. Disc. by Schmidt, 1861. In southerly end of the nebula *h* 399.

2375. Disc. by Winnecke, 1867. Schönfeld's obsns. partly confirm, partly contradict Winnecke's elements, given in Second Catalogue. Yendell's obsns. also render them doubtful. The star requires further investigation before the question can be settled.

2445. Susp. by Espin, 1887; proved by Hartwig.

2478. Disc. by Krueger, 1870–74; conf. by Schönfeld. 10^M foll. 20^s, 2′.3 N; 10^M pr. 11^s, 3′.5 N.

2509. Disc. by Schmidt, 1847. Elements of Second Catalogue retained. Definitive investigation not completed.

2528. Disc. by Hind, 1848. Light-curve variable. Variations near max. frequently very slow. 12^M, 2′.5 N; $12^M.5$ pr. 4^s, 1′ S; 9^M foll. 25^s, 3′ N.

2530. Disc. at H.C.O., 1896.

2539. Disc. at Bonn, 1855. Light-curve flat at max. Obsns. of Lalande and Bessel are harmonious with the new elements.

2583. Disc. by Gould, 1872; conf. by Williams and Roberts.

2610. Disc. by Sawyer, 1887; conf. by Chandler. Elements of Second Catalogue retained, as recent obsns. give no certain correction. Light-oscillations occupy 5^h.

2625. Disc. by Baxendell, 1880; conf. by Knott and Chandler.

2676. Disc. by Gould, 1873. Light-curve has rudely alternating bright and faint minima.

2684. Disc. by Hind, 1856. Light-curve flat at max. A star $9^M.5$ foll. 19^s, 4′ N; $9^M.3$ pr. 25^s, 3′ N.

2690. Susp. by Kapteyn, 1889; proved by Hartwig, who suggests period of 415^d, or one-half of the same.

2691. Disc. by Schönfeld, 1865. $12^M.7$ pr. 1^s, 0′.3 S; $12^M.2$ foll. 4^s, 0′.1 N.

2735. Disc. by Baxendell, 1879; conf. by Schmidt. Period and light-curve very irregular, with secondary max. and min. Elements uncertain.

2742. Disc. by Hind, 1848. $11^M.5$ foll. 4^s, 0′.6 S; 12^M pr. 5^s, 1′.6 N.

2776. Disc. at H.C.O., 1895.

2780. Disc. by Hind, 1848. A halt frequently occurs during increase, at about $9^M.5$. $12^M.5$ pr. 1^s, 2′.3 S; 11^M pr. 12^s, 3′ N.

2783. Disc. by Gould, 1873.

2815. Disc. by Hind, 1855. Light-variation of a unique character. The star remains at or near min., about 13^M, most of the time, suddenly brightens to about $9^M.3$, and diminishes again in 5–12^d to min. Irregular periods, from 2 to 5 mos., average 86.3^d. For purpose of approx. prediction the epoch of last observed max. is given as epoch of catalogue. For comparison-stars and light-scale see Winnecke, *A.N.* 1120.

2852. Disc. by Williams, 1886; conf. by Roberts. The former thinks period is $4\frac{1}{2}^d$; the latter, about half of this.

2857. Disc. by Pickering, 1881; conf. by Chandler. 10^M foll. 26^s, 4′ N; 11^M pr. 16^s, 1′.5 N; 13^M foll. 2^s, 1′.5 S.

2946. Disc. by Schwerd, 1829. 10^M foll. 6^s, 4′.4 S; 12^M pr. 4^s, 1′.5 S.

2976. Disc. by Auwers, 1870. Occasionally secondary phases near max. 11^M foll. 4^s on parallel; $10^M.5$ foll. 18^s, 0′.3 N.

3040. Disc. by Roberts, 1892.

3055. Disc. by Roberts, 1892; conf. by Fleming. Roberts finds the period to be $1^d.0826736$, or one-half of this. I have adopted the latter as more probable.

3060. Disc. by Chacornac, 1853. Light-variation, occasionally at least, slow near max. 11^M pr. 3^s, 7′ N.

3087. Disc. by Roberts, 1892.

3109. Disc. by Hind, 1848. Schönfeld's elements retained, since 6 min. by Yendell in 1890 give unimportant deviations. Light-oscillations occupy $21\frac{1}{2}^h$.

3128. Susp. by Weiss; proved by Holetschek, 1890. This letter assigned because the var. of the star to which the letter *R* was assigned (*Uran. Argent.* p. 297), has not yet been confirmed.

3170. Disc. by Hind, 1848. Var. near max. sometimes slow, sometimes rapid. 11^M pr. 12^s on parallel; 12^M foll. 7^s, 0′.3 N.

3184. Disc. by Hind, 1851. 10^M foll. 6^s, 3′ N; $10^M\,5$ pr. 4^s, 2′.5 N.

3186. Disc. by Hind, 1850. Elements give minimum-epoch only, as light-curve is too flat near max. to determine the latter.

3264. Disc. at H.C.O., 1895.

3355. Disc. by Roberts, 1892.

3407. Disc. by Paul, 1888; conf. by Sawyer. Elements of Second Catalogue retained, since recent obsns. show no certain correction. Light-oscillations occupy about $3\frac{1}{2}^h$.

3409. Disc. by Gould, 1871; conf. by Roberts. Roberts's obsns. not entirely consistent with Gould's period of $4^d.25$.

3416. Disc. by Woods, 1894; conf. by Roberts. Light-oscillations occupy about one-tenth of period, or $15^h.2$. Stationary at minimum for $6^h.5$.

3417. Disc. by Roberts, 1895.

3418. Disc. by Gould, 1871; conf. by Tebbutt.

3425. Disc. by Skinner, 1894; conf. by H. M. Parkhurst, and also by Paul, whose elements are given.

3467. Disc. at H.C.O., 1895. Inserted in the catalogue with much hesitation, notwithstanding the confirmation by both Pickering and Wendell; since plates on the same or successive nights show discordances equal to one-half the total asserted range of variation. Although this is not inconsistent with an extremely short period, I have marked the variability as doubtful in the catalogue.

3477. Disc. by Schönfeld, 1863. $10^{M}.5$ foll. 10^{s}, 2′ N.

3493. Disc. by Koch, 1782. The periodical inequality of the elements in the Second Catalogue certainly exists. But the observations of the last few years show that it is complicated with other unknown terms. Until the law is developed by future observations, it seems best to use only the uniform period of the catalogue for prediction of phases.

3495. Disc. by Gould, 1871; conf. by Roberts.

3567. Disc. by Becker, 1882; conf. by Chandler. $11^{M}.5$ foll. 5^{s}, 1′.2 N.

3569. Disc. at H.C.O., 1895.

3633. Disc. by Gould, 1872; conf. by Roberts.

3637. Disc. by Gould, 1871; conf. by Roberts. Light-curve regular.

3662. Disc. at H.C.O., 1895.

3712. Disc. by Peters, 1876. Schönfeld thought it variable. Certainly seen by no one except Peters and the DM. observers. The writer has never been able to see the star, although it was sought for many times in different years. H. M. Parkhurst, who has kept careful watch of it, concludes that it is probably not variable. The variability is extremely doubtful.

3767. Disc. by Roberts, 1893.

3796. Disc. by Gould, 1871; conf. by Espin and Yendell. Espin's period not confirmed.

3825. Disc. by Pogson, 1853. Light-curve very variable.

3847. Disc. by Burchell, 1827. Fluctuations very capricious.

3881. Susp. by Gould; proved by Chandler, 1888. Large irregularities in period. Elements of Second Catalogue very untrustworthy.

3890. Disc. by Peters, 1880; conf. by H. M. Parkhurst. A max. obsd. by Yendell, 1893, contradicts Parkhurst's elements given in Second Catalogue. For stars of identification see *A.N.* 99, 114.

3908. Disc. by Gould, 1877; conf. by Upton and Roberts. The latter thinks period is about 18^{h}.

3922. Disc. by Roberts, 1891.

3934. Disc. by Winnecke, 1861. Variations very small, and, according to some observers, doubtful. Schönfeld found, very uncertainly, period of 160^{d}, from Winnecke's obsns. *α Crateris* pr. 43^{s}, 1′.2 N; 9^{M} pr. 5^{s}; $8^{M}.5$ foll. 10^{s}, 2′.5 S.

3983. Disc. at H.C.O., 1895, and assumed there to belong to the so-called new stars. An 11^{M} star, north 110″; another 80″ south preceding.

3994. Disc. by Chacornac, 1856. Increase apparently slower than decrease by Chandler's obsns. $11^{M}.5$ foll. 6^{s}, 1′.7 S.

4160. Disc. by Peters, 1862. Variation not confirmed by any other observer. Schönfeld and Chandler have never certainly seen the star; and it is doubtful whether H. M. Parkhurst's obsns. refer to the right object.

4225. Disc. at H.C.O., 1895.

4260. Disc. at H.C.O., 1895.

4300. Disc. by Peters, 1871; conf. by Schönfeld and Chandler. A period of about 340^{d} is consistent with a large part of the very defective data. $11^{M}.5$ foll. 2^{s}, 0′.1 N.

4315. Disc. by Schönfeld, 1856. $7^{M}.5$ pr. 13^{s}, 2′.2 N.

4364. Disc. by Roberts, 1891.

4377. Disc. by Boguslawski, 1849. 11^{M} pr. 8^{s}, 2′ N; 12^{M} foll. 1^{s}, 2′ N; $11^{M}.5$ foll. 12^{s}, 2′ N; $11^{M}.5$ pr. 2^{s}, 4′ N.

4407. Disc. by Karlinski, 1867. Increase rapid. 8^{M} pr. 5^{s}, 3′.5 S; 10^{M} pr. 5^{s}, 0′.5 N; 8^{M} foll. 18^{s}, 1′ S.

4415. Disc. by Roberts, 1895.

4429. Disc. by Roberts, 1891.

4435. Disc. at H.C.O., 1889. Its variability does not seem to be sufficiently beyond doubt.

4488. Disc. at H.C.O., 1895.

4492. Disc. by Henry, 1874; conf. by Chandler. 8^{M} foll. 19^{s}, 1′ S; 11^{M} foll. 12^{s}, 2′.5 N.

4511. Disc. at Bonn, 1860.

4521. Disc. by Harding, 1809. See investigation *A.J.* VIII, 164.

4536. Disc. by Gould, 1871; conf. by Upton.

4557. Disc. by Pogson, 1853.

4596. Disc. by Harding, 1831. Periodic inequality of small range indicated. 10^{M} pr. 9^{s}, 1′ N.

4611. Disc. by Roberts, 1891.

4731. Susp. by Espin, 1891; proved by Yendell.

4805. Disc. by Schönfeld, 1866. Light-curve very regular.

4816. Disc by Goldschmidt, 1857. Increase somewhat irregular, decrease more uniform. Star isolated, and identification easy.

4826. Susp. by Montanari, 1672 (1670?); proved by Maraldi, 1704. Elements of catalogue are based on obsns. since 1784 only, the attempt to reconcile Hevel's, Montanari's and Maraldi's max. having been given over for the present. The principal epoch of catalogue corresponds to Ep. 170 of investigation in *A.N.* 103, 225.

4847. Disc. by Hind, 1852.

4885. Disc. at H.C.O., 1895, and announced as a "new" star. Its variability is established by Campbell's and Hussey's observations, which also correct the error in the original announcement as to its position relative to the nebula N.G.C. 5253. The star follows $1^{s}.4$, north 0′.3. The assumption that the object is of a new or temporary character appears to be unwarranted by the facts. It is indeed contradicted by Thome's testimony, which is explicit.

The hypothesis depends on the assumption that Cord. DM. —31°10536 is identical with the nebula. But both nebula and star were simultaneously seen on at least one occasion at Cordoba, and on another the question of their identity was especially examined. The Cordoba observations show that the so-called "new" star was always found, as 9^{M} or $9\frac{1}{2}^{M}$, whenever looked for, on five nights in three different years. The facts are all consistent with variability of the ordinary kind, either periodic—in perhaps 374^{d}—or irregular.

4896. Disc. by Markwick, 1894, and afterwards independently, apparently, at H.C.O. Confirmed also by Roberts. The previous suspicion of the star by Kapteyn loses its weight from the fact that it is based on the large discordance of two plates taken on the same evening, half an hour apart, notwithstanding that the star has a well ascertained period of three mos.

4940. Disc. by Sawyer, 1888; conf. by Yendell.

4948. Disc. by Espin, 1888; conf. by Chandler.

5037. Disc. by Peters, 1880; conf. by H. M. Parkhurst.

5070. Disc. by Palisa, 1880; conf. by Chandler. 9^{M} pr. 12^{s}, 2′ S; 10^{M} pr. 7^{s}, 2′ N.

5095. Disc. by Gould, 1871; conf. by Roberts.

5097. Disc. by Baxendell, 1860. Only one appearance known. Schönfeld suggested that it may belong to the class of new stars.

5131. Disc. at H.C.O., by Miss Wells, 1896.

5144. Disc. by H. M. Parkhurst, 1894; conf. by Yendell. Parkhurst's idea that it is of the *Algol*-type not yet verified.

5156. Disc. by Baxendell, 1859; conf. by Chandler, 1888, and Yendell, 1893. A star $7^{M}.3$, directly south 2′.8, renders obsn. difficult.

5157. Disc. at Bonn, 1860. Variation of period, as indicated by the elements, very certainly established.

5174. Disc. at H.C.O., 1892; conf. by Hartwig.

5190. Disc. by Hencke, 1858. Light-curve somewhat irregular.

5191. Disc. at H.C.O., 1895.

5192. Disc. by Roberts, 1894.

5194. Disc. by Dunér, 1884; conf. by Chandler. Observed max. show considerable deviations.

5237. Disc. at Bonn, 1858.

5249. Disc. by Schönfeld, 1882; conf. by Chandler.

5274. Disc. by Schmidt, 1867; conf. by Schwab.

5319. Disc. by Gould, 1873; conf. by Roberts.

5321. Disc. at H.C.O., 1894.

5338. Disc. by Baxendell, 1880; conf. by Schwab. Light-curve flat at maximum; minimum sharply marked.

5374. Disc. by Schmidt, 1859. Epoch of catalogue-elements corresponds to Ep. 391 of Schönfeld. Schmidt found an inequality of 9-yrs. cycle in period. I suspect that this is not real, but a subjective effect, dependent on hour-angle at which min. are obsd. The subject is reserved for definitive investigation. Light-oscillations occupy 12^{h}.

5396. Disc. at H.C.O., 1896.

5402. Disc. by Gould, 187–; conf. by Roberts, who also confirms Gould's period.

5405. Disc. by Skinner, 1895; conf. by Paul. Hartwig suggests that period is perhaps 225^{d}.

5430. Disc. by Palisa, 1878; conf. by Chandler. $10^{M}.5$ foll. 7^{s} on parallel; 13^{M} pr. 4^{s}, 0′.2 N; $13^{M}.5$ pr. 1^{s}, 1′ N.

5438. Disc. by Bauschinger, 1887; conf. by Chandler. Period uncertain.

5465. Disc. by Gould, 1871; conf. by Roberts.

5484. Disc. by Winnecke, 1869. Elements of Second Catalogue retained, as they represent obsns. to date, without appreciable certain correction. See investigation *A.J.* IX, 97. Light-oscillations occupy nearly 10^{h}.

5494. Disc. by Borrelly, 1872. 13^{M} pr. 2^{s}, 2′ N; $12^{M}.5$ foll. 5^{s}. 2′.5 N.

5501. Disc. by Harding, 1828. Increase more rapid than decrease. 11^{M} pr. 8^{s}, 0′.5 N; $12^{M}.7$ foll. 2^{s}, 0′.4 N.

5504. Disc. by Hencke, 1860.

5511. Disc. at H.C.O., 1892; conf. by Chandler.

5533. Disc. at H.C.O., 1893; conf. by Campbell.

5566. Disc. at H.C.O., 1895.

5583. Disc. by Peters, 1878; conf. by H. M. Parkhurst.

5593. Disc. by Peters, 1878; conf. by H. M. Parkhurst.

5601. Disc. at H.C.O., 1895; conf. by Chandler.

5617. Disc. by Peters, 1878; conf. by Chandler.

5644. Disc. by Peters, 1879. S.DM. gives R.A. 10^{s} smaller.

5667. Disc. by Pigott, 1795. Remains frequently nearly unchanged, near max., then diminishes at irregular intervals suddenly to min., and after repeated large oscillations resumes its normal unchanging condition.

5675. Disc. by Dunér, 1878; conf. by Schmidt. Secondary phases near max. sometimes marked.

5677. Disc. by Harding, 1826. Star isolated and identification easy.

5682. Disc. by Gould, 1884.

5688. Disc. by Pogson, 1858. Recent obsns. of H. M. Parkhurst make elements of Second Catalogue very doubtful. 12^{M} pr. 3^{s}, 1′.2 S.

5704. Disc. by Peters, 1885; conf. by H. M. Parkhurst.

5713. Disc. by Gould, 187–; conf. by Roberts, who gives period as $6^{d}.3$.

5732. Disc. by Birmingham, 1866. See note to Schönfeld's Second Catalogue for history of its appearance.

5750. Disc. by Roberts, 1893.

5758. Disc. by Gore, 1890; conf. by Yendell.

5761. Disc. by Peters, 1883; conf. by H. M. Parkhurst.

5768. Disc. by Espin, 1894; conf. by Yendell.

5770. Disc. at Bonn, 1855. Identification easy.

5776. Disc. by Peters, 1876; conf. by H. M. Parkhurst.

5795. Disc. by Palisa, 1870; conf. by Schmidt. 10^{M} pr. 8^{s}, 1′ N; 10^{M} foll. 10^{s}, 3′ S.

5823. Disc. by Roberts, 189–.

5826. Disc. by Auwers, 1860, independently by Pogson, one week later. Position, $0^s.29$ foll. 2″.7 N of the center of cluster *Messier* 80. Not since seen.

5830. Disc. by Chacornac, 1853. Light-curve very variable; marked secondary phases. Increase from 12^M rapid. 8^M pr. 24^s, 2′ N; 9^M foll. 10^s, 3′ N.

5831. Disc. by Chacornac, 1854. $9^M.4$ foll. 9^s, 0′.2 N.

5856. Disc. by Schönfeld, 1881; conf. by Chandler. 11^M pr. 13^s on parallel; 12^M foll. 13^s, 4′ N; 10^M foll. 34^s, 1′ N.

5860. Disc. by Pogson, 1863. Decreased from 9^M to invisibility in 12 days. Not seen by any one else.

5887. Disc. by Dunér, 1881; conf. by Chandler.

5889. Disc. by Hencke, 1860. Elements will not satisfy Bessel's obsn., hence period is probably variable. 9^M pr. 12^s, 3′.3 N.

5903. Disc. by Peters, 1876; conf. by Chandler. Elements very uncertain.

5912. Disc. by Baxendell, 1857.

5928. Disc. by Pogson, 1860. No max. observed for twelve years past, hence elements very uncertain for prediction. 10^M foll. 5^s, 9′ S; 10^M pr. 5^s, 2′.5 S.

5931. Disc. by Pogson, 1854. Recent obsns. confirm Schönfeld's elements, which are retained. Light-curve variable. $11^M.5$ pr. 6^s, 3′ N; 12^M pr. 13^s, 0′.2 N.

5948. Disc. by Pickering, 1881; conf. by Chandler. Period 4 to 6 mos., very irregular.

5949. Disc. by Roberts, 1891. Light-oscillations occupy about one-tenth of the period, or $10^h.3$.

5950. Disc. by Dunér, 1880; conf. by Chandler.

5952. Disc. by Chandler, 1882; conf. by Yendell. The former, in 1882–83, found period $20^d.5$; the latter in 1889–93, period of $20^d.6$.

5955. Disc. by Geelmuyden, 1876; conf. by Hartwig. $8^M.5$ foll. 35^s, 1′.5 S; 11^M foll. 2^s, 3′ S.

6005. Susp. by Espin, 1892; proved by Yendell.

6044. Disc. at Bonn, 1856. Decrease unusually rapid immediately after max. $9^M.7$ foll. 9^s, 1′.4 S; 6^M foll. 11^s, 1′.9 N.

6050. Disc. at H.C.O., 1890; conf. by Campbell.

6062. Susp. by Thome, 1892; proved by Fleming.

6071. Disc. by Roberts, 1894.

6083. Disc. by Hind, 1848. At present visible as $12^M.5$, without change since 1867.

6101. Disc. at H.C.O., 1893.

6132. Disc. by Pogson, 1853. $10^M.5$ foll. 6^s, 4′ S; $10^M.5$ pr. 2^s, 6′ S. A small nebula, not in Herschel's G.C. or Dreyer's N.G.C., foll. 36^s, 2′ S.

6170. Disc. at H.C.O., 1895.

6181. Disc. by W. Herschel, 1795. Very irregular oscillations in periods of 2 to 4 mos.

6189. Disc. by Gould, 1871; conf. in 1881 by Sawyer, who also first recognized its character as of the *Algol*-type. See investigations *A.J.* VII, 129–140, and XIII, 46. Light-oscillations occupy 5^h.

6202. Disc. by Schmidt, 1869 (?). Schmidt gave period about 37–40 days. Very rapid secondary oscillations near min. remarked by Schmidt, and confirmed by Schwab.

6207. Disc. at H.C.O., 1893; conf. by Chandler.

6225. Disc. by Anderson, 1895; conf. by Becker and Halm.

6268. Disc. by Brunowski and Fabricius, 1604. See note to Schönfeld's Second Catalogue.

6275. Disc. at H.C.O., 1892. Place adopted is 4^m 6^s pr., and 1′ S of that given by H.C.O., *A.N.* CXXX, 126.

6331. Disc. at H.C.O., 1895.

6368. Disc. by Schmidt, 1866. Elements of Second Catalogue retained, although correction at present amounts to about — $1^d.0$.

6404. Disc. by Sawyer, 1888; conf. by Chandler.

6442. Variability discovered by Müller and Kempf from discordances in their photometric observations, 1891, and previously. Chandler found it (beginning of August, 1894) to be of *Algol*-type, with period of 3^d 23^h $50^m.0$. This was confirmed (middle of August) by Yendell and Sawyer. Hartwig (September) independently made the same discovery, and also found that a secondary minimum occurred about three hours earlier than the midway point between the principal minima, — a fact independently discovered by Dunér a few days later.

6449. Susp. by Espin, 1894; proved by J. A. Parkhurst, who also rectified the error of position in original announcement.

6472. Disc. by Schmidt, 1866. Elements of Second Catalogue retained.

6500. Disc. at H.C.O., 1893; conf. by Gould's previous zone-observations.

6512. Disc. at Bonn, 1857. 10^M pr. 3^s, 0′.9 N.

6546. Disc. by Gould, 1874; conf. by Roberts.

6573. Disc. by Sawyer, 1886; conf. by Chandler. Elements of Second Catalogue retained.

6608. Susp. by Thome, 1892; proved at H.C.O.

6613. Susp. by Müller and Kempf, 1891; proved by Yendell, who finds period as given in the catalogue.

6624. Disc. by Baxendell, 1860. $11^M.5$ foll. 3^s, 0′.1 N.

6636. Disc. by Schmidt, 1866. Elements of Second Catalogue retained.

6653. Susp. by Birmingham; proved by Safarik, 1886; further confirmed by Yendell, and by discordant photographs of Espin and Wolf.

6682. Disc. by Espin, 1886; conf. by Chandler.

6726. Disc. by Winnecke, 1860. Irregularly variable in period of 3 to 5 mos.

6733. Disc. by Pigott, 1795. Argelander found bright and faint minima, usually alternating, and this has been confirmed by all subsequent observers.

6758. Disc. by Goodricke, 1784. Light-curve double. Secondary min. about midway.

6760. Disc. by Thome, 1872; conf. by Upton.

6791. Disc. by Baxendell, 1856. Pannekoek's inequality of period hardly seems sustained by the observations.

6806. Disc. by Schmidt, 1866. The period of 6^{d}, found from his earlier obsns., not conf. by the later ones.

6811. Disc. by Schmidt, 1866. Period given in Catalogue is Schmidt's.

6812. Disc. by Schmidt, 1876.

6834. Recognized by various observers, Knott, 1871; Schmidt, 1872; Safarik, 1884; Sawyer, 1892.

6849. Disc. at Bonn, 1856. Secondary fluctuations near max. Light-curve very variable. $9^{M}.6$ pr. 12^{s}, 0′.3 S; $10^{M}.6$ pr. 4^{s}, 0′.5 N.

6854. Susp. by Gould, verified by Chandler, 1894; also by Yendell.

6871. Disc. by Anderson, 1895; conf. by Yendell.

6888. Disc. at H.C.O., 1896.

6892. Disc. at H.C.O., 1896.

6894. Disc. by Espin, 1893; conf. by H. M. Parkhurst.

6900. Disc. by De Ball, 1893; conf. by Schwab. Holetschek suggests the period given.

6903. Disc. by Pogson, 1863. $11^{M}.5$ foll. 10^{s}, 0′.5 N.

6905. Disc. by Pogson, 1858; 11^{M} pr. 1^{s}, 0′.4 S; $10^{M}.8$ pr. 4^{s}, 1′ N.

6921. Disc. by Pogson, 1860. 11^{M} foll. 24^{s}, 2′.5 S.

6923. Disc. by Peters, 1888; conf. by Pickering.

6940. Espin's first suspicion was verified by his later obsns, 1894, and also by Yendell.

6943. Disc. by Espin, 1886; conf. by Yendell and Chandler.

6984. Disc. by Sawyer, 1886; conf. by Chandler.

7045. Disc. by Pogson, 1852. *θ Cygni* pr. 22^{s}, 0′.7 N; 9^{M} foll. 2^{s}, 1′.5 N.

7077. Disc. at H.C.O., 1896.

7085. Disc. by Pickering, 1890; conf. by Porro.

7101. Disc. by Anthelm, 1670. See note to Schönfeld's Second Catalogue.

7106. Susp. by Hind, 1861; proved by Baxendell, 1862.

7118. Disc. at H.C.O., 1894; conf. by Yendell.

7120. Disc. by Kirch, 1686. See investigation in *A.J.* X, 103. An $11^{M}.5$ pr. 10^{s}, 1′.9 S; $11^{M}.5$ foll. 3^{s}, 1′ S; $11^{M}.5$ foll. 6^{s}, 0′.1 N.

7122. Disc. at H.C.O., 1894.

7124. Disc. by Pigott, 1784.

7139. Susp. by Thome, 1891; conf. at H.C.O.

7149. Disc. by Gore, 1885; conf. by Chandler.

7151. Disc. at H.C.O., 1891; conf. by Campbell.

7155. Disc. by Espin, 1895; conf. at H.C.O.

7162. Disc. at H.C.O., 1895.

7192. Disc. by Espin, 1887; conf. by Baxendell, Jr.

7220. Disc. at Bonn, 1860. Secondary phases near max. $8^{M}.9$ foll. 1^{s}, 0′.8 N.

7234. Disc. by Hind, 1848. 13^{M} dist. 20″, pos.-angle 355°.

7240. Disc. by Espin; conf. by Yendell.

7242. Disc. by Baxendell, 1863. Extraordinary and unexplained irregularities in period. 9^{M} foll. 1^{s}, 1′.5 S.

7245. Disc. at H.C.O., 1895.

7247. Disc. by Deichmüller, 1893; conf. by Yendell.

7252. Disc. by Peters, 1872; conf. by H. M. Parkhurst and Chandler. For stars of identification see *A.N.* 109. 120.

7257. Disc. by Baxendell, 1859. Double light-curve, like *β Lyrae*. Second max. and second min. follow principal ones about 35^{d}, respectively. Reversals of light-curve occurred in 1874 and 1883, so that between these dates the secondary minima were fainter than the principal minima.

7259. Disc. by Espin, 1887; conf. by Chandler. Dunér thinks period may be 380^{d}; Parkhurst, 120^{d}; but it is doubtful whether the star is regularly periodic. Place from Bessel. DM. decl. is 2′.4 smaller.

7260. Disc. by DeBall, 1894; conf. by Holetschek.

7261. Found by Hencke, 1851, and suspected to be an asteroid, until Schönfeld, 1859, proved variability. 12^{M} pr. 2^{s}, 1′ S.

7266. Paul finds the star in the place given in the Catalogue to be variable, and Campbell's observations are also accordant in establishing its variability. In 1890 the H.C.O. announced a variable in this region, but about 20′ distant, or prec. $1^{m}\,42^{s}$, and 4′ south. Although this original announcement was repeated in different publications, and cannot therefore be a typographical error, Paul's explanation of the source of the confusion is so probable, that we are not warranted in assuming that there are two variables in this locality. The star given as 7255 in the Revised Supplement, *A.J.* 347, is therefore to be struck out, and Paul's and Campbell's star, as given in this catalogue, substituted.

7285. Disc. by Janson, 1600.

7299. Disc. by Knott, 1871. Knott thinks brightness at minimum is systematically variable. $8^{M}.5$ foll. 5^{s}, 0′.7 N.

7351. Disc. by Espin, 1885; conf. by Yendell.

7399. Disc. at H.C.O., by Miss Wells, 1895; conf. by Arthur Searle, as of the *Algol*-type.

7404. Disc. at H.C.O., 1894; conf. by Paul, whose elements are adopted in catalogue, since those of Hartwig (1889 Sept. 13 +281E) do not accord with Paul's observations.

7428. Disc. by Birmingham, 1881; conf. by Schmidt. Second max. follows principal one about two mos.

7431. Disc. by Baxendell, 1860. $8^{M}.3$ pr. 1^{s}, 0′.9 N.

7435. Disc. by Becker, 1895; conf. by Kobold and Hartwig.

7437. Disc. by Chandler, 1886; conf. by Yendell. The former finds brightness at min. variable; the latter confirms this fact, and finds that the phenomenon is periodic in a cycle of 21 periods; but considers this last to be a subjective effect of varying parallactic angle under which the obsns. are made at different times of the year.

7444. Disc. by Baxendell, 1863. Possibly a secondary max. near principal one. Decrease unusually rapid. 11^{M} pr. 3^{s}, 2′.7 N; $10^{M}.1$ foll. 12^{s}, 0′.1 N.

7446. Susp. by D'Arrest, 1874; conf. by Espin, Gore and Chandler.

7448. Disc. at H.C.O., 1891; conf. by Hartwig.

7450. Disc. by De Ball, 1891; conf. by Yendell.

7455. Disc. by Pogson, 1858. $8^{M}.5$ foll. 20^{s}, $7'$ S; 10^{M} pr. 15^{s}, $6'$ S.

7456. Disc. by Espin, 1888; conf. by Chandler, 1888, Yendell, 1890.

7458. Disc. at H.C.O., 1891; conf. by Hartwig, Yendell and H. M. Parkhurst.

7459. Disc. by Schmidt, 1864. Period about one year, by Schmidt's obsns. Light-variations exceedingly small, and for the most part unnoticeable. Variability not sufficiently confirmed to be regarded as certain.

7468. Disc. by Goldschmidt, 1861.

7482. Disc. at H.C.O., 1896.

7483. Disc. by Sawyer, 1885; conf. by Chandler. Elements of Second Catalogue retained.

7488. Disc. by Chandler, 1886; conf. by Sawyer. *Algol*-type. The extraordinary anomalies signalized in *A.J.* VIII, 130 and IX, 92 are explained by Dunér *A.J.* XII, 1, whose elements are adopted in the Catalogue. Dunér gives also the additional term $\pm 2^{s}.2$(E-792), where upper sign is for even epochs, lower for odd. Chandler found brightness at min. to be variable, and Yendell's obsns. confirm. Light-oscillations occupy about 8^{h}.

7492. Disc. by Espin, 1893; conf. by Hartwig.

7495. Disc. at H.C.O., 1895.

7502. Disc. by Anderson, 1895; conf. by Yendell.

7544. Disc. at H.C.O., 1895.

7560. Disc. at Bonn, 1858. $9^{M}.5$ foll. 6^{s}, $0'.3$ N.

7571. Disc. by Peters, 1867; conf. by H. M. Parkhurst. For stars of identification see *A.N.* 109; 121.

7577. Disc. by Peters, 1872; conf. by H. M. Parkhurst. For stars of identification see *A.N.* 109; 122.

7590. Disc. by Skinner, 1895; conf. by Paul. Borrelly had previously suspected, from comparison of Chacornac's chart with heavens.

7609. Disc. by Ceraski, 1878; conf. by Knott.

7659. Disc. by Hind, 1854. 9^{M} pr. 5^{s}, $3'.9$ N.

7733. Disc. by Peters, 1884; conf. by H. M. Parkhurst. Period may perhaps be 412^{d}, or double that of the Catalogue.

7754. Disc. by Gore, 1885; conf. by Sawyer.

7779. Disc. by Hencke, 1858. Light-curve flat at max.

7783. Susp. by Espin, 1890; proved by Yendell and Reed.

7787. Disc. by Schmidt, 1876.

7795. Disc. by Safarik, 1885, and independently by Yendell, 1892; conf. by Sawyer and H. M. Parkhurst. Hartwig, in 1895, mentions that he suspected var. in 1881.

7803. Susp. by Hind, 1848; conf. by Argelander. Argelander's period of 432^{d} not borne out by Schmidt's and other obsns.

7813. Disc. at H.C.O., 1895.

7896. Disc. at H.C.O., 1895.

7907. Disc. by Peters, 1881; conf. by H. M. Parkhurst.

7909. Susp. by Weiss; proved by Holetschek, 1890.

7944. Disc. by Hind, 1863. 11^{M} pr. 13^{s}, $1'.5$ N. R.A. of DM. is 6^{s} too small.

7994. Disc. by Gould, 1884; conf. by Thome and H. M. Parkhurst.

7999. Disc. at H.C.O., 1895; conf. by Hartwig.

8039. Disc. at H.C.O., 1896.

8040. Disc. at H.C.O., 1896.

8068. Disc. by Fleming, 1891; conf. by Reed, 1893.

8073. Disc. by Goodricke, 1784. The variation of the period indicated by the elements is certain.

8093. Disc. by Gould, 1884.

8116. Disc. by Espin, 1885; conf. by Yendell and J. A. Parkhurst.

8153. Disc. by Deichmüller, 1883; conf. by Chandler. Increase from 13^{M} to 10^{M} very rapid. $9^{M}.3$ foll. 20^{s}, $2'.8$ N; 11^{M} foll. 7^{s}, $2'.8$ N; 11^{M} pr. 13^{s}, $2'.5$ N.

8230. Disc. by Argelander, 1853. Decrease from 10^{M} rapid. $7^{M}.5$ foll. 31^{s}, $4'$ N; 10^{M} foll. 9^{s}, $3'$ S.

8273. Disc. by Schmidt, 1847. Argelander found period 41^{d}; Schönfeld thinks irregular oscillations. in period of $30–50^{d}$, more probable.

8290. Disc. by Hind, 1848. 11^{M} foll. 10^{s}, $0'.2$ N; $10^{M}.5$ pr. 9^{s}, $3'$ N.

8324. Disc. by Anderson, 1893; conf. by Hartwig.

8369. Disc. by Anderson, 1895; conf. by Hartwig.

8373. Disc. by Marth, 1864 (?). No faint stars near, and identification easy. Increase from 11^{M} rather slow.

8512. Disc. by Harding, 1811. Identification easy. Increase from 10^{M} quite rapid.

8588. Disc. by Gould, 1884.

8591. Disc. by Chandler, 1882; conf. by Yendell and Sawyer.

8594. Disc. at H.C.O., 1892.

8597. Disc. by Peters, 1879; conf. by H. M. Parkhurst. For stars of identification, see *A.N.* 109, 123.

8598. Disc. by Chandler, 1894; conf. by Yendell.

8600. Disc. by Pogson, 1853. 10^{M} pr. $0^{s}.5$, $0'.6$ N.

8604. Disc. at H.C.O., 1895.

8622. Disc. by Skinner, 1894; conf. by Paul.

UNCONFIRMED STARS.

At the end of the Second Catalogue was given a list of stars whose variability had been asserted or suspected on more or less plausible grounds, but which required further verification. Similar shorter lists were given in the Supplements.

Many of these stars have since been confirmed and removed to the list of known variables in the present Catalogue. Many others have been sufficiently observed to establish their probable constancy, and justify their being dropped from further notice. The remainder have either not been observed at all, so far as I know, or are still unsettled; observers being still at variance with regard to the reality of their fluctuation. These last I have therefore repeated in the following list, which consists for the most part, however, of stars not formerly included. The selection of the stars to be added could not very well be governed by any well defined principle. The list makes no pretension to completeness, and may be regarded as a heterogeneous collection, useful as a working list of objects needing examination.

The last column contains a reference to some source where more particular information may be found. In the case of the *Astron. Journal* and *Astr. Nachrichten* the number of the periodical alone is given, for the latter authority in Italic numerals. For many of these stars several references will be found in the periodical publications of the last few years, but the limitations of space forbid my quoting here more than one.

No.	1855.0 R.A.	1855.0 Decl.	Observed Range	Reference
	h m s	° ′	M M	
(149)	0 22 31	−15 39.9	4.9– 5.9	Ur. Arg.
(185)	28 47	−55 37.5	5.7– 6.5	Ur. Arg.
(268)	42 31	−35 42.6	9.1–10.5?	371
(271)	42 45	+62 7.9	8.7– 9.4	*3286*
(355)	0 56 23	+61 35.4	8.7– 9.5	*3286*
(571)	1 33 0	− 7 21.6	8.4– 9.2	300
(660)	48 53	−68 39.5	6.6– 7.5	Ur. Arg.
(705)	1 56 13	−63 28.0	>7 7.7	Ur. Arg.
(780)	2 6 53	+57 51.2	8.7–10.5?	
(857)	20 35	− 0 26.3	8 – 9	346
(969)	38 10	+57 47.8	8.0– 9.2	*3286*
(1017)	46 26	+51 3.3	8.9– 9.6	*3286*
(1078)	2 56 11	+59 55.1	8.6– 9.5	*3232*
(1285)	3 30 48	+51 1.8	7.5– 8.9	*3352*
(1341)	3 41 9	+35 16.7	9 –12 ?	300
(1617)	4 27 19	−30 3.8	4.3– 5.0	Ur. Arg.
(1636)	32 3	−63 7.4	5.8– 6.4	
(1637)	29 29	+41 17	9.2–	*3286*
(1709)	42 20	+15 31.7	8.0– 9.1	2825
(1745)	48 18	−16 39.3	5.4– 6.0	300
(1772)	53 11	−12 15.1	4.7– 5.7	300
(1771)	52 11	+50 25.0	7.6– 8.9	*3352*
(1801)	55 21	+68 28.2	7.8– 9.3	300
(1804)	4 58 15	+ 3 50.3	9.5–12	367
(1915)	5 21 18	− 1 19.1	10.9–13<	300
(1918)	22 22	− 1 12.6	4.8– 6.0	Ur. Arg.
(1961)	24 36	− 0 21.6	2.2– 2.7	300
(1978)	27 13	+10 8.3	5.7– 6.7	Ur. Arg.
(1980)	27 56	− 6 6.6	$5\frac{1}{2}$ – $7\frac{1}{2}$	Ur. Arg.
(1988)	5 29 –	− 5 31	. . .	300
(1993)	5 27 22	+68 36.1	9 –10	328
(2130)	5 52 48	− 3 5.0	5.1– 5.9	Ur. Arg.
(2235)	6 10 14	− 1 31.3	8 – 9.3	
(2267)	15 5	+25 5.0	8.9– 9.7	*3352*
(2282)	17 41	+19 10	8.8– 9.5	*3352*
(2335)	6 26 39	+15 26.6	7.1– 7.6	
(2609)	7 12 7	+25 15.4	8.0– 9.2	*3352*
(2725)	32 23	−31 48.3	6.7– 7.5	Ur. Arg.
(2740)	28 54	+80 51.8	7.7– 8.7	*3352*
(2741)	35 15	−31 19.6	6.5– 7.5	300
(2757)	37 41	−28 4.1	4.8– 5.6	Ur. Arg.
(2788)	7 43 11	−40 17.5	6.5– 7.2	Ur. Arg.
(2903)	8 1 16	+19 50.0	9.7– ?	300
(2928)	6 32	−42 33.4	5.1– 5.8	Ur. Arg.
(2931)	5 24	+44 27	8.7– 9.5	*3332*
(3031)	23 22	−26 51.1	6.9– 7.7	Ur. Arg.
(3172)	46 58	−36 0.0	6.5– 7.5	Ur. Arg.
(3179)	47 13	+17 46.9	6.8– 7.9	346
(3197)	8 50 23	+11 23.4	8.5– 9.3	300
(3262)	9 1 41	−25 16.5	4.3– 5.1	Ur. Arg.
(3614)	10 0 42	−51 29.0	6.5– 7.5	300
(3682)	12 15	−60 36.5	3.3– 4.5	Ur. Arg.
(3734)	21 31	−73 17.7	4.2– 5.1	Ur. Arg.
(3795)	10 30 55	−58 48.7	5.4– 6.3	Ur. Arg.
(4033)	11 9 59	−31 8.2	7.0– 7.7	Ur. Arg.
(4169)	32 48	−64 35.7	5.4– 6.1	Ur. Arg.
(4238)	11 41 0	−11 23.1	6.3 <7.0	
(4389)	12 9 13	+55 38.0	8.5– 9.3	*3352*
(4495)	26 47	−22 35.7	$2\frac{1}{2}$ – $3\frac{1}{2}$	300
(4535)	12 33 43	+56 38.6	7.9– 8.8	*M. Not. 56*

No.	1855.0 R.A.	1855.0 Decl.	Observed Range	Reference
	h m s	° ′	M M	
(4639)	12 50 43	−35 29.4	6.3– 7.0	Ur. Arg.
(4665)	55 18	+ 5 57.9	8.8– 9.7	*3347*
(4685)	58 12	−58 1.6	6.2– 7.5	Ur. Arg.
(4686)	12 58 23	−40 48.6	6.0– 6.6	Ur. Arg.
(4786)	13 15 15	−16 58.5	5.2– 5.9	Ur. Arg.
(4854)	26 30	−32 33.9	6.5 – 7.2	Ur. Arg.
(4905)	35 29	+29 6.7	6.5– 7.2	300
(4971)	46 56	+55 44.5	8.0– 9.0	
(5013)	51 20	−76 5.6	5.5– 6.2	Ur. Arg.
(5026)	13 55 23	− 1 40.8	7.5– 8.5	
(5159)	14 17 40	+26 22.0	7.2– 8.2	V. J. S. 28
(5291)	14 38 33	−56 3.2	6.0– 7.0	Ur. Arg.
(5562)	15 22 22	−71 23	6.0– 7.0	347
(5572)	25 33	−49 1.1	7.0– 9.5	Ur. Arg.
(5626)	35 17	−10 27.7	7.0– 8.8	300
(5642)	37 29	−34 13.5	5.5– 6.5	Ur. Arg.
(5690)	15 44 47	−72 2.2	6.7– 7.4	Ur. Arg.
(5880)	16 18 47	+51 4.1	8.1– 9.5	*3352*
(6036)	16 43 40	− 5 55.3	8.5–10 ?	
(6185)	17 5 57	−69 57.8	5.1– 6.0	Ur. Arg.
(6470)	56 7	+ 2 30.5	8.2– 8.8	300
(6490)	17 59 48	+22 3.8	8.8–13 ?	*3281*
(6502)	18 1 54	+28 44.4	3.4– 3.8	300
(6549)	9 54	+36 37.4	8.5–<10	*3329*
(6572)	12 36	−24 58.5	6 – 7½	Ur. Arg.
(6699)	35 38	+55 28.6	8.5–<9.5	*3171*
(6716)	37 49	+36 49.4	7.2– 8.5	319
(6749)	42 28	− 8 1.0	7.1– 8.0	300
(6769)	45 30	−22 51.1	9.7 ?	319
(6828)	18 56 0	+14 21.7	7.0– 7.8	346
(6897)	19 8 27	+49 24.2	8.7–10.2 ?	319
(6915)	9 53	−19 19.4	9.4–10.1	300
(6924)	12 29	+37 21.3	7.1– 8.0	*3286*
(6991)	22 54	+ 2 36.4	6.3– 7.2	Ur. Arg.
(7010)	19 26 15	+17 26.0	6.3–<13	300
(7020)	19 27 13	−25 2.0	5.3– 6.7	300
(7059)	34 23	+12 50.2	7 – 8	339
(7097)	40 51	+15 41	8.8–10	*3304*
(7205)	19 59 7	+36 21.5	8.0– 9.2	300
(7235)	20 3 59	+25 51.8	8.5– 9.4	346
(7238)	5 3	+47 25.4	7.7– 8.9	300
(7268)	8 37	−21 45.6	7.0– 7.7	300
(7279)	11 53	+49 29.6	8.7– 9.6	300
(7302)	14 28	−16 28.2	10.4 <12	300
(7305)	15 54	+36 28.4	8.2– 9.7	*M. Not.* 54
(7331)	19 4	−28 44.1	7.4– 8.4	*3347*
(7349)	22 27	−12 42.7	6.8– 8.5	Ur. Arg.
(7375)	25 24	−62 1.4	4.7– 5.3	Ur. Arg.
(7397)	28 36	−67 16.0	5.2– 6.1	Ur. Arg.
(7401)	31 18	+17 45.5	6.0– 6.7	*M. Not.* 56
(7416)	33 26	−19 34.2	9 –11	
(7451)	39 45	+16 23.5	7.0– 8.0	*3286*
(7481)	45 13	+33 57.4	7.9– 9.0	300
(7484)	45 52	+45 40	8.7–<9.5	*3232*
(7502)	48 24	+27 30.5	4.9– 6.4	300
(7524)	20 53 11	+63 57.6	7.8– 9.5	*3286*
(7595)	21 4 46	+60 28.7	8.6– 9.3	*3286*
(7646)	11 19	−50 32.6	6.1– 7.3	Ur. Arg.
(7675)	15 53	−55 16.0	6.0– 6.6	Ur. Arg.
(7878)	21 51 14	+39 13.2	7.8– 8.8	*3286*
(8006)	22 12 44	+56 15.7	8.4– 9.5	300
(8104)	28 17	− 8 20.8	9 –11.5	300
(8106)	28 48	+ 8 14.0	9.5–<13	300
(8149)	22 32 47	−19 35.2	4.8– 5.6	Ur. Arg.
(8407)	23 19 6	+44 15.3	7.9– 9.0	*3286*
(8458)	27 16	−43 25.0	4.4– 5.1	Ur. Arg.
(8528)	39 0	+ 2 40.8	4.8– 6.0	300
(8562)	44 45	−16 39.7	8.2– 9.3	*3347*
(8637)	23 57 10	+42 44.6	7.2– 8.4	*3286*

Variables in Stellar Clusters. It has been announced that Prof. S. I. Bailey, in charge of the Boyden Observatory at Arequipa, has found a large number of cases of variability in various stellar clusters, and that they have been confirmed by Prof. Pickering and Mrs. Fleming. Reference may be made to *A. N.* 2986, 3223, 3321 and 3354 for more particular information. Following is a tabular statement of the places of these clusters and the number of variables said to have been confirmed in each.

	1855.0 R.A.	1855.0 Decl.	
	h m s	° ′	
N. G. C. 104	0 17 33	−72 53.3	6 var.
" 362	0 57 19	−71 37.6	5 "
N. G. C. 5272	13 35 30	+29 6.6	87 var.
" 5904	15 11 13	+ 2 36.8	46 "
" 6656	18 27 33	−24 1.2	4 "
" 7089	21 26 0	− 1 27.8	2 "
" 7099	21 32 8	−23 50.0	3 "

Two variables had already been found by Packer, 1890, (see (5481) — *Librae*, Second Catalogue) in the fourth cluster above given. One of these, not included in the above list, was independently confirmed by Bailey. Fourteen other variables in the same cluster, and nine others in no. 5272, were also found by Bailey, but have not been confirmed and are not included in the above count.

Missing Durchmusterung Stars. Prof. KREUTZ some time ago by letter made the pertinent suggestion that it might be well to include, in the list of unconfirmed stars of this Catalogue, those stars of the *Durchmusterung* which have been missed from the heavens by various observers. Undoubtedly many of these objects are quite as much deserving of attention as the directly announced instances of suspected variability, and it is much to be desired that a complete list of them should be collected and printed for the convenience of variable-star observers. I cannot pretend to do this here; but append a partial list. In all these cases, except the four marked with an asterisk, an examination of the Bonn records, by Profs. SCHÖNFELD, DEICHMÜLLER or KREUTZ, has shown the originals to be clear, leaving little doubt of the actual existence of the stars in question at the time the DM. observations were made. This list could undoubtedly be much extended by a more thorough search, and indeed quite indefinitely if we included all the stars in the DM. of the 9ᴹ.5 class which have been found to be not brighter than 10ᴹ.5 or 11ᴹ. But for reasons familiar to astronomers, it is not likely that this latter class would yield any considerable number of cases of variability. On the other hand, there is good reason to anticipate that the examination of the missing stars given below would be fruitful in this respect.

DM.	1855.0 R.A.	1855.0 Decl.		Authority
	h m s	° ′	M	
8 33	0 13 38	+ 8 36.3	9.5	Deichmüller
9 34	0 14 47	+ 9 52.5	9.5	Deichmüller
8 215	1 13 57	+ 8 55.3	9.5	Tempel
20 235	1 22 46	+20 8.5	9.5	Weiss
15 379	2 35 55	+15 15.1	9.5	J. Palisa
7 183	3 4 55	+ 7 34.1	9.5	Weiss
8 558	3 36 32	+ 8 56.4	9.5	J. Palisa
23 612	3 56 34	+23 35.0	9.5	Oppolzer
15 587	4 0 17	+15 50.4	9.5	Peter
28 647	4 13 54	+28 13.3	9.5	Weiss
13 703	4 31 21	+13 26.0	9.5	J. Palisa
42 1196	5 1 26	+42 2.3	9.5	Deichmüller
28 1466	7 37 41	+28 14.5	9.5	Deichmüller
28 1477	7 40 19	+28 51.6	9.4	Deichmüller
28 1484	7 41 32	+28 56.8	9.5	Deichmüller
32 1636	7 43 57	+32 40.8	9.5	Deichmüller
28 1561	8 0 5	+28 56.6	9.5	Deichmüller
7 2277	10 11 52	+ 7 55.8	9.5	J. Palisa
10 2233	10 51 34	+10 56.5	9.5	Deichmüller
7 2425	11 5 21	+ 7 28.5	9.5	Schmidt
7 3076	15 55 47	+ 7 0.7	9.5	von Boinik
*4 4332	19 57 23	+ 4 22.9	9.5	Chandler
*46 3019	20 37 50	+46 30.1	9.2	Espin
*43 3749	20 47 21	+43 44.5	9.5	Espin
*42 3891	20 47 30	+42 41.8	9.5	Espin
7 5106	23 50 28	+ 7 20.0	9.5	Tempel

Suspected Variables in the Cordoba Durchmusterung. In the introductions to the two published volumes of the Cordoba *Durchmusterung* Dr. THOME has collected the stars which, in the prosecution of that work, showed such discrepancies in the recorded magnitudes as to raise suspicion of their variability. The evidence in a large number of these cases is striking, and indeed has been verified in a considerable number of them by other observers; and there is little doubt that further examination of these rich materials will result in the confirmation of many more. The lists are too long to be reproduced here, but it appears desirable to print at least a selection of what seem to be the most promising cases. Since it will be most conveniently used in conjunction with the Cordoba Catalogues the equinox of 1875 is employed.

Cord. DM.	1875.0 R.A.	1875.0 Decl.	Observed Limits
	h m s	° ′	M M
−33 185	0 27 1	−33 33.9	8.5–<10.5
22 177	0 29 9	22 26.6	8.3–<10.5
25 1197	2 54 59	25 15.5	8.7–<10.5
38 2639	6 21 3	38 52.3	9 –<10.5
23 4020	6 28 6	23 10.4	8.5– 10.7
29 3464	6 42 2	29 3.6	8.5–<10.5
21 7693	8 59 34	21 31.6	8 –<10.5
22 7617	9 42 53	22 33.6	8.5–<10.5
33 6410	9 44 39	33 58.3	7.5– 10
24 12600	16 1 25	24 31.4	9 –<10.5
37 11462	17 10 47	37 13.5	7.5– 9
35 11936	17 39 54	35 30.0	8.2–<10.5
24 13621	17 47 36	24 6.7	8.5– 10.5
41 12260	17 50 7	41 4.7	8.5– 10
33 12697	17 51 41	33 52.9	7.5– 10
33 13321	18 24 54	33 14.0	9.7–<10.5
38 13089	18 38 58	38 17.2	9 –<10.5
22 13401	18 46 42	22 50.1	8 – 9.5
27 15202	20 54 54	27 34.8	9 –<10.5
22 15937	22 25 8	−22 52.6	8.7–<10.5

TABLE FOR CONVERTING JULIAN AND CALENDAR DATES.

	1895	1896	1897	1898	1899	1900
Jan. 0	241 3194	3559	3925	4290	4655	5020
Feb. 0	3225	3590	3956	4321	4686	5051
Mar. 0	3253	3619	3984	4349	4714	5079
Apr. 0	3284	3650	4015	4380	4745	5110
May 0	3314	3680	4045	4410	4775	5140
June 0	3345	3711	4076	4441	4806	5171
July 0	3375	3741	4106	4471	4836	5201
Aug. 0	3406	3772	4137	4502	4867	5232
Sept. 0	3437	3803	4168	4533	4898	5263
Oct. 0	3467	3833	4198	4563	4928	5293
Nov. 0	3498	3864	4229	4594	4959	5324
Dec. 0	3528	3894	4259	4624	4989	5354

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p. 146. Corrected place of 22 *V Sculptoris* (1900) $0^h\ 3^m\ 34^s$. —39° 47′.1 ; (1855) $0^h\ 1^m\ 16^s$. —40° 2′.2

PUBLISHED IN BOSTON, TRI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed July 7.*

THE

ASTRONOMICAL JOURNAL.

No. 380.

VOL. XVI. BOSTON, 1896 JULY 22. NO. 20

NOTE ON THE VARIABLE STAR 6442 *Z HERCULIS*,

BY PAUL S. YENDELL.

In the course of the observations made by Müller and Kempf for the Potsdam Photometric *Durchmusterung*, this star was observed four times, as follows:

1888 June 1	$16^h\ 22^m$	sid. Time	$7^M.94$
1890 Sept. 19	19 48		7.48
1891 Oct. 1	20 1		7.42
1891 Oct. 6	19 50		7.85

The first and last of the above observations evidently found the star very nearly at its minimum, while by applying either Hartwig's or Dunér's elements, we find that at the time of the other two, it must have been at its normal light.

To be considered in any sense definitive, any elements for the star's variation must account for the observations of 1888 June 1 and 1891 Oct. 6. This is fairly the case with the elements of Hartwig, as shown in his paper in the *Astronomische Nachrichten*, 136, 331. These elements, however, do not satisfy my observations of 1895.

On the other hand, the elements of Dunér, while accounting fairly for the observations of 1894 and 1895, entirely fail to satisfy these early Potsdam observations.

The comparison is as follows, the O—C being simply the difference between the time of observation and the computed time of minimum, the former, in the first and last observations, being probably not more than half an hour from the actual minimum, in either case.

Epoch	Approx. Gr. M.T.	Comp. Time	O—C
—1152	1881 June 1.448	June 1.963	—0.515
— 733	1890 Sept. 19.292	Sept. 20.236	—0.944
— 545	1891 Oct. 1.269	Sept. 30.485	+0.784
— 540	Oct. 6.248	Oct. 6.518	—0.270

The conclusion seems to me unavoidable, that the star's period is variable, though the character and value of the variation cannot at present be determined.

Prof. Dunér, in his paper in Vol. XVI, p. 105, of this Journal, alludes to my observed minimum of 1895 April 23, as "evidently erroneous." I am by no means disposed to accept this rather summary estimate, as the minimum in question happens to be one of the best defined and best observed of the entire series, and entirely free from any suspicion of prepossession, as is indicated by the weight attached to it.

It is an easy and convenient matter to dispose in this manner of an observation which does not confirm one's own theory; but I have, myself, during the past year, had a sharp lesson on the error of the practice, as my first minimum of *U Pegasi*, observed in 1894, which I had been inclined to pass over lightly, as hopelessly discordant, proves to have contained the key to the whole enigma of the star's period. The present state of our knowledge of the variations of *Z Herculis* does not seem to me to justify the rejection of any such minimum.

In an equally summary manner, Prof. Dunér proceeds to dispose of my observed magnitudes, quoting Lindemann's value of the normal light, $6^M.89$, as a basis. My magnitude estimates for the comparison-stars were founded directly upon the values given by Müller and Kempf, and agree very fairly therewith. Their observations of 1890 Sept. 19 and 1891 Oct. 1, as above remarked, must have been made when the star was at its normal light, and the mean of the two is $7^M.45$. My estimate of the normal light, from nineteen observations, is $7^M.30$, the average minimum light being at the even minima $7^M.94$, and at the odd ones $7^M.75$. This agrees much more nearly with the measures of Muller and Kempf than with those of Lindemann, and the observed ranges of variation, $0^M.64$ and $0^M.45$, account fully for the difficulty of observation.

As will be seen, the light-range observed by me at the odd minima accords very well with that found by Prof. Dunér, but at the even ones it is about one-third less. We have no evidence thus far that the star's minimum light is constant; my own observations lead me to suspect that the light of several stars of this type fluctuates to some degree at this phase, and it is possible that this may be the case with *Z Herculis*. And it should be borne in mind that Prof. Dunér's strictures on my observations are based, not on other simultaneous observations, but on those made during the previous year by various observers.

Dorchester, Mass., 1896 *June* 25.

SUNSPOT OBSERVATIONS,

MADE WITH A 4½-INCH REFRACTOR AT PHILADELPHIA, PENNA., UNTIL MARCH 26, AND AFTER THAT DATE AT BERWYN, PENNA.,

BY A. W. QUIMBY.

1896	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Jan. 1	10h	1	4	19	3	fair
2	10	–	3	11	3	poor
3	10	–	2	8	1	poor
4	2	–	2	9	3	poor
5	12	–	4	18	3	poor
6	11	1	5	19	1	poor
8	11	–	3	11	2	poor
10	12	–	1	1	1	poor
11	12	–	1	1	4	fair
12	9	2	2	9	3	fair
13	10	–	2	7	3	poor
14	9	–	2	4	2	poor
15	10	–	1	2	1	poor
16	10	1	2	2	2	poor
18	10	–	2	2	2	poor
20	11	–	2	2	–	fair
21	12	–	2	2	–	poor
22	9	–	2	2	1	fair
25	9	1	3	3	1	fair
26	9	2	5	10	3	good
27	10	1	5	22	3	fair
28	10	–	5	31	3	fair
29	10	–	5	19	2	fair
30	10	–	2	9	2	fair
31	12	1	3	18	1	fair
Feb. 2	2	1	4	21	3	fair
6	10	1	4	14	2	fair
7	10	–	4	14	1	poor
8	11	1	5	15	3	poor
9	2	–	2	6	1	v.poor
10	3	–	4	12	1	fair
11	9	–	3	10	3	poor
12	9	–	3	9	2	poor
14	9	1	4	14	2	poor
15	9	–	3	14	1	poor
16	1	–	2	13	1	poor
17	9	–	1	4	1	poor
18	9	1	2	6	2	poor
19	9	1	3	12	2	poor
20	9	–	3	18	3	poor
21	8	–	2	22	2	poor
22	11	3	5	58	1	poor
23	9	–	5	63	1	poor
24	10	–	4	75	1	poor
25	10	–	4	47	1	poor
27	9	–	5	50	2	fair
28	9	1	5	38	2	fair
Mar. 1	5	–	4	28	2	poor
2	1	–	4	17	2	poor
3	9	–	4	22	2	poor
4	9	1	5	27	2	poor
5	9	–	5	21	1	poor
Mar. 6	9h	–	4	10	1	poor
7	3	–	3	12	2	poor
8	10	1	5	27	2	fair
9	10	–	3	6	2	poor
12	3	–	2	7	2	poor
13	9	1	3	10	4	fair
14	8	–	2	5	2	poor
17	9	–	2	6	3	fair
18	8	1	3	8	2	poor
19	4		3	5	3	poor
20	10	1	3	5	2	poor
21	10	–	3	5	2	poor
*22	4	–	3	11	2	poor
24	9	1	3	15	1	poor
25	9	1	1	22	1	fair
*26	9	1	3	11	1	poor
*27	7	–	3	11	–	poor
28	9	–	3	18	2	fair
29	1	1	3	22	2	fair
30	9	–	3	32	2	fair
31	9	2	5	50	2	fair
Apr. 2	12	3	7	12	–	poor
3	9	1	6	29	2	poor
4	7	–	6	20	–	poor
5	8	1	6	31	3	poor
6	2	–	3	32	4	fair
7	8	1	4	52	1	fair
8	7	–	4	30	2	poor
9	9	–	3	45	3	good
11	11	–	1	8	–	poor
12	9	–	1	12	1	fair
13	7	–	1	5	2	fair
14	4	1	1	4	3	fair
15	8	–	1	2	3	good
16	9	–	–	–	2	fair
17	9	–	–	–	2	poor
18	2	1	1	8	2	fair
19	9	–	1	10	1	poor
20	9	3	4	22	1	fair
21	12	1	4	19	1	fair
22	9	4	3	6	2	poor
23	8	1	4	13	4	fair
25	12	–	3	25	3	fair
26	8	–	3	30	3	fair
27	7	1	4	37	3	good
28	8	–	1	6	–	v.poor
29	7	–	3	7	1	good
30	12	–	2	10	3	fair
May 3	7	–	1	13	–	poor
4	9	1	2	11	2	fair
5	8	–	2	12	2	fair
6	7	–	1	6	3	fair
May 7	7h	1	2	10	–	poor
8	8	–	2	7	1	poor
9	8	–	1	3	1	fair
10	8	–	2	3	2	fair
11	7	–	3	5	2	fair
12	8	–	1	1	1	fair
13	7	–	2	5	1	fair
14	7	–	1	1	2	fair
15	2	–	1	3	2	fair
16	8	–	1	3	1	fair
17	8	–	–	–	2	fair
18	8	1	1	4	3	fair
19	8	–	1	12	2	good
21	8	–	1	4	–	v.poor
22	8	1	2	8	2	fair
23	8	–	2	5	2	fair
24	8	–	1	3	3	fair
25	11	1	2	4	–	poor
26	12	2	4	20	2	fair
27	7	–	4	61	3	good
28	7	1	4	72	3	good
29	10	–	3	74	1	good
30	–	–	2	38	1	poor
31	3	1	2	30	3	fair
June 1	7	1	3	38	4	good
2	7	1	4	44	2	good
3	7	–	4	20	2	fair
4	3	1	4	12	3	good
5	7	1	3	11	4	fair
6	7	–	3	8	4	fair
7	7	–	3	12	3	fair
8	12	1	3	8	1	fair
9	3	1	4	25	1	good
10	7	–	4	25	1	fair
11	7	1	4	78	2	good
12	7	–	4	48	2	poor
13	7	1	4	71	2	fair
14	7	–	3	44	2	poor
15	7	–	3	63	2	fair
16	12	–	3	31	1	poor
17	8	–	3	15	1	poor
18	7	–	2	12	2	fair
19	7	1	2	8	1	fair
20	7	–	2	9	2	fair
21	8	–	1	17	2	good
22	7	2	3	41	2	good
23	7	–	3	68	2	good
26	12	1	3	67	2	good
27	10	–	3	42	2	fair
28	1	1	4	22	3	fair
29	7	–	3	22	3	fair
30	6	1	3	15	3	fair

* 2¼-inch objective, 36-inch focus, power 72.

NOTE ON THE PERIODIC COMET OF BROOKS AND JAVELLE,

By CHARLES LANE POOR.

The observation of M. Javelle is sufficient to determine very closely the elements of this interesting body, and also to throw some light upon the vexed question as to the possible identity with Comet of Lexell 1770. It will be remembered that in the *Astronomical Journal*, nos. 302 and 303, I expressed the elements, which represent the former appearance of this comet in 1889, in terms of an indeterminate quantity, ν, the limits of variation of which were placed at ±40. In all my subsequent work this quantity was retained and carried through the computations. A simple comparison of my ephemeris with the observation above mentioned is, therefore, sufficient to determine an approximate value of ν, and thence the values of the elements.

Making this comparison, I find the following differences, in the sense Observed *minus* Computed.

$$\Delta\alpha = -0^{m}\ 24^{s}.61$$
$$\Delta\delta = -2'\ 36''.00$$

From these I find the value of ν to be

From comparison in α,	-3.85
From comparison in δ,	-3.48
Mean value,	-3.66

Correcting the elements given in *Astronomical Journal* no. 320, by introducing this value of ν, I find for the elements of the present appearance of this body, the following:

Epoch 1896 Oct. 23.5 Greenwich M.T.

$$\left.\begin{array}{rcrrr} & & {}^{\circ} & {}' & {}'' \\ \pi & = & 1 & 48 & 53.69 \\ \Omega & = & 18 & 1 & 7.76 \\ i & = & 6 & 3 & 34.08 \\ \omega & = & 343 & 47 & 45.93 \end{array}\right\} 1896.0$$

$$\log a = 0.5673648$$
$$\log e = 9.6715950$$
$$\log \mu = 2.6989593$$
$$T = 1896\ \text{Nov.}\ 4.16177\ \text{Greenwich M.T.}$$

And these elements, I think, will be found to be very close to the definitive ones.

As to Identity with Lexell's Comet of 1770. The very small value above found for ν leaves the conclusions, reached in my paper in *Astronomical Journal* no. 303, practically unchanged. It was there pointed out that large disturbances by *Saturn* were necessary to establish the identity of the two bodies. No such disturbances were indicated by the mean set of elements, and no such disturbances are indicated by the introduction of the above value of ν. Small disturbances by *Saturn* are indeed indicated, but they are far too small to effect the result.

On the other hand the small negative value found for ν points strongly to an extremely close appulse to *Jupiter* in 1791. It is highly probable that in that year the comet suffered great disturbances, and that its orbit was then greatly changed. The data are not yet sufficient to enable us to determine the character of those changes. But, as was clearly pointed out in the above mentioned article, if such an appulse took place in 1791, the present comet cannot possibly be the same as Lexell's.

Unless there is some error in my previous work, or unless quantities of the second order, there of necessity neglected, materially affect the results, it would now seem to be reasonably well established that the periodic comet of Brooks and Javelle is not identical with that of Lexell.

1896 *June* 25.

ECLIPSES AND CHRONOLOGY: A REPLY TO MR. LYNN,

By JOHN N. STOCKWELL.

In no. 375 of this Journal, Mr. W. T. Lynn has endeavored to show that the battle between Eugenius and Theodosius the Great, took place early in September instead of late in November, as the account given by Zosimus very clearly shows. Now there are some reasons for believing, that Mr. Lynn is mistaken in his views of the subject, and that the narratives of the different historians when properly understood, clearly indicate that the battle took place in the winter rather than early in September. Mr. Lynn's conclusions are based on a statement of the ecclesiastical historian Socratės, who says that the battle took place early in September, which is, he says, a much more *likely* time for it to take place, than late in November. But he omits to give any reason *why* it was more likely to occur at that time than at a later date. Had he said a more *desirable* time, his statement would not have been open to criticism. It seems to me that the most likely time for a battle to occur at a given place would be such time as the opposing armies may be able to meet at such place. A few words, however, in regard to the narratives concerning the battle, may not be out of place here.

The historian Zosimus distinctly speaks of an eclipse of the sun having taken place on the *first* day of the battle, while other historians mention a great storm of wind and dust which happened on the *second* day, and contributed largely to the success of the arms of Theodosius. Therefore, there is nothing incompatible in the accounts of the different historians; both may be, and probably are, correct; but the date of the battle according to the eclipse does not correspond with that given by Socrates; and as the date of the wind-storm cannot be determined by calculation, there is perhaps room for reasonable doubt as to which historian, Socrates or Zosimus, is correct; and these doubts can only be removed by means of collateral evidence which may be found in the narratives of the different historians.

I have already remarked that the most likely time for the battle to occur was such time as the two armies could be brought together at a given point. Now according to the compiler of the *Constantinopolitan History* as given in the eighth edition of the *Encyclopedia Britannica*, the army of Theodosius after leaving Constantinople arrived at Adrianople on the fifteenth day of June. We therefore know the position of the army of Theodosius at a given date, and it only remains to inquire what length of time would be required for that army to march from Adrianople to Aquileia, a city near which the battle was fought. The great-circle distance between those cities is about eight hundred English miles; but the army would be obliged to march over a broken and mountainous country, and the distance actually traversed would probably not fall much short of twelve hundred miles. The interval of time between June 15 and September 1 is only seventy-seven days; but if we knew the daily rate of progress of the army, we could easily tell at what time it would reach its destination. That rate, however, being unknown, we are obliged to seek other sources of information, the most reliable of which seems to be the expedition of Napoleon to Moscow in the year 1812. The army of Napoleon left Dresden on May 29, and reached Moscow about the middle of September; an interval of one hundred and ten days. Now the great-circle distance between Dresden and Moscow is about one thousand miles; but the surface of the country is unbroken and wholly free from mountains. The natural obstacles encountered by Napoleon in that expedition could not therefore have been greater than were encountered by Theodosius in his expedition against Arbogastes and Eugenius. Napoleon has never been accused of being sluggish in his movements; and I think we are fully justified in allowing Theodosius as much time in his journey to Aquileia, as was consumed by Napoleon in his journey to Moscow. This would bring the date of his arrival at that place up to the early part of October; and I think we may regard it as physically impossible that the battle took place at the time assigned by the historian Socrates.

But this is not all. For the poet Claudian, whose description of the wind-storm at the time of the second battle is quoted by Mr. Lynn, in speaking of the battlefield also says, *that the snow was colored red, and the cold river smoked with the blood of the slain.* Now it seems extremely improbable that the ground should be covered with snow in the latitude of southern or central Europe in the early part of September; for it is very seldom that snow falls in that latitude before the middle of November, even in this country, which is much colder than Europe. These allusions however, strongly remind one of winter; and quite as strongly confirm the testimony of Zosimus that the battle and the eclipse were contemporaneous events.

Cleveland, 1896 *June* 1.

OBSERVATIONS AND ELEMENTS OF TWO VARIABLES,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 12-INCH AND 26-INCH EQUATORIALS.

By H. M. PAUL.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

The following observations and approximate elements relate to two of the four variables discovered by Mr. Skinner in the progress of his zone-observations at this observatory. The lower limits of magnitude rest upon light-scales extended downward from the DM. at the assumed rate of 10 observed steps per magnitude, and hence are somewhat uncertain. I suspect that what I have called $12^{M}.0$ is really considerably fainter, but how much I have as yet no data for estimating.

3425. *X Hydrae.*

Since the observations published in *A.J.* XV, 103, I have observations, on 16 nights, between 1895 Nov. 18 and 1896 May 15. These give a rise from about $11^{M}.8$ on the first date [probably a little after minimum] to a maximum of $8^{M}.4$ at about 1896 April 2 [241 3652], with a fall to $9^{M}.2$ on May 15. The following formula for maxima,

$$1896 \text{ April } 2 = 241\,3652 + 296\,E,$$

with $M - m = 151^{d}$, and a range of variation from $8^{M}.4$ to $12^{M}.0$ may be regarded as more accurate elements than those first suggested in *A.J.* XIV, 160, and adopted by Chandler in his Revised Supplement [*A.J.* XV, 81]. The period is the same, but the epoch of the new elements is 8 days earlier.

8622. *W Ceti.*

Since the announcement by Mr. Skinner of his discovery and of my first observations of this star [*A.J.* XV, 48], I have 30 observations during an interval of 207 days, covering the following phases: From about $9^{M}.6$, observed in morning twilight 1895 June 22 and 23, the star fell slowly to a minimum of about $12^{M}.0$ on 1895 Oct. 5 [241 3472], and then rose more rapidly to about $8^{M}.7$ on 1896 Jan. 3. Two observations, on Jan. 11 and 15, showed little further change, and bad weather prevented later observations; but, for reasons stated below, I hardly think a maximum had been reached.

The interval between this rising slope and the corresponding parts of the rise noted in the first announcement [*A.J.* XV, 48] would indicate a period somewhat near 340 days. But the only elements which, with a constant period approximating this, will fairly satisfy the observations of

Lalande, Argelander, Schoenfeld, and 18 H.C.O. plates,* are the following:

1896 Feb. 10 = 241 3600 + 350 E.

As there may be considerable inequality of period involved in the interval since the observations of Lalande and Argelander, the above can be considered only a rough approximation to period and epoch, the latter being especially doubtful since, if the period be approximately correct, the maxima have lately been occurring near conjunction with the sun, and are still too near for very accurate determination unless favored with clear twilight horizons near the critical period.

Washington, 1896 *June* 12.

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* The Schoenfeld and H.C.O. observations were kindly furnished to Mr. Skinner by Dr. Küstner and Prof. Pickering. Also a letter from M. Tisserand states that this star has not yet [1895 July 3] been observed at Paris in the revision of Lalande. It may be well to notice here that the Lalande-Baily right-ascension [Lal. 47087] is 1ᵐ too small, as noted by Argelander in BB. 7:239.

OBSERVATIONS OF COMET *b* 1896 (SWIFT),

MADE AT THE LICK OBSERVATORY, WITH THE 12-INCH EQUATORIAL TELESCOPE,

By R. G. AITKEN.

1896 Mt. Hamilton M.T.	*	No. Comp.	☄ — * Δα	☄ — * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
May 11 12 6 4	4	d12 , 9	−0 48.71	−7 2.7	1 49 19.40	+65 49 45.6	n9.675	0.904
12 13 38 10	5	10 , 7	−2 47.73	+1 20.7	1 41 44.65	+66 34 24.4	n9.961	0.792
13 8 20 7	6	d13 , 12	−0 28.76	+2 32.4	1 36 3.89	+67 1 55.3	9.742	0.896
23 15 30 50	7	6	. . . .	−1 8.8	. . . .	+71 17 47.8	. .	n9.732
15 37 23	7	d12	+0 49.39	. . . .	0 21 59.09	. . . .	n0.135	. .
24 13 20 32	9	d14 , 10	−0 31.99	+3 11.5	0 15 32.28	+71 30 32.1	n0.164	0.465
15 8 7	11	12 , 6	+1 21.53	+2 32.6	0 14 58.17	+71 31 30.5	n0.152	n0.362
25 14 18 0	12	d19 , 10	−0 18.69	−2 29.9	0 8 12.53	+71 43 47.1	n0.172	9.903
26 9 40 3	14	d 8 , 14	+0 28.63	+2 26.8	0 2 30.20	+71 52 47.6	n9.875	0.872
11 54 54	14	d16 , 13	−0 13.29	+3 35.5	0 1 48.28	+71 53 56.3	n0.132	0.668

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
4	1 50 9.78	−1.67	+65 56 45.9	+2.4	Fearnley, Christiania A.G. Catal. 352
5	1 44 34.08	−1.70	+66 33 2.0	+1.7	Fearnley, Christiania A.G. Catal. 336
6	1 36 34.39	−1.74	+67 2 22.0	+0.9	Fearnley, Christiania A.G. Catal. 321
7	0 21 11.04	−1.34	+71 19 3.5	−6.9	Micrometer-comparison with (8) [Zone 71°16)
8	0 19 50.31	−1.34	+71 13 49.1	−6.9	⅓(2 Rogers, Cambridge A.G. Catal. 15 + Dorpat,
9	0 16 5.64	−1.37	+71 27 27.8	−7.2	Micrometer-comparison with (10)
10	0 12 0.88	−1.37	+71 26 21.8	−7.2	Dorpat, Zone 71°10
11	0 13 38.01	−1.37	+71 29 5.1	−7.2	Micrometer-comparison with (10)
12	0 8 32.53	−1.31	+71 46 24.2	−7.2	Micrometer-comparison with (13)
13	0 16 52.46	−1.31	+71 40 18.4	−7.2	Argelander, Bonn VI, 71°11
14	0 2 2.92	−1.35	+71 50 28.7	−7.9	Micrometer-comparison with (15)
15	23 55 0.73	−1.35	+71 49 19.4	−7.9	Dorpat, Zone 71°1245

(*d*) indicates that Δα was measured directly. On May 12, the wind shook the telescope badly during the observation. The measures of May 23–26 were made in full moonlight, and were in consequence very difficult.

Mt. Hamilton, 1896 *June* 8.

OBSERVATIONS OF MINOR PLANET (387),

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

By JOHN H. OGBURN.

1895 Albany M.T.	*	No. comp.	Planet — * Δα	Planet — * Δδ	Planet's apparent α	Planet's apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
May 1 12 50 28	1	6	−0 34.45	− 0 32.1	18 5 49.06	+ 0 46 32.8	n9.414	0.770
6 11 33 36	2	12 , 5	+0 16.86	− 0 13.9	18 6 28.68	+ 1 5 16.3	n9.517	0.770
12 7 21	3	8	+0 22.48	− 1 50.8	18 6 28.80	+ 1 5 21.9	n9.488	0.770
7 11 20 51	4	4	+2 10.62	+ 2 4.5	18 6 31.37	+ 1 8 36.5	n9.540	0.770
22 11 3 59	5	6	+2 14.09	+ 1 19.6	18 3 34.69	+ 1 35 45.3	n9.328	0.766
23 10 19 22	6	7	+2 13.03	+ 1 29.6	18 3 9.79	+ 1 35 14.4	n9.551	0.764

1895 Albany M.T.		*	No. comp.	Planet — *		Planet's apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
May 29	10 23 56	7	10 , 6	−0 10.98	+ 4 57.5	18 0 2.20	+ 1 29 28.4	n9.500	0.766
June 1	11 39 16	8	8	+1 38.61	+ 3 48.3	17 58 6.91	+ 1 22 5.1	n9.252	0.745
2	10 32 11	8	8	+1 0.44	+ 0 54.1	17 57 28.73	+ 1 19 11.1	n9.446	0.765
9	9 41 43	9	8	+1 19.41	+ 7 51.6	17 52 19.69	+ 0 48 52.0	n9.483	0.771
10	10 55 10	9	7	+0 28.94	+ 1 54.7	17 51 29.23	+ 0 42 58.2	n9.260	0.770
11	9 7 2	9	8	−0 15.87	− 3 40.9	17 50 14.41	+ 0 37 19.7	n9.527	0.775
17	10 30 36	10	7	−1 52.01	− 5 12.8	17 45 39.90	− 0 6 7.7	n9.239	0.775
28	10 12 59	11	6	−2 9.91	− 9 7.4	17 36 26.91	− 1 51 48.3	n8.685	0.790
July 2	10 41 3	12	7	+1 29.63	+ 6 16.9	17 33 23.58	− 2 42 34.5	n7.993	0.796
3	9 25 9	12	7	+0 48.74	− 5 32.3	17 32 42.71	− 2 51 23.6	n9.175	0.796
17	9 51 10	13	9	−0 4.00	− 7 6.9	17 24 54.83	− 6 7 22.5	8.127	0.821
18	11 5 11	14	4	+4 8.29	+ 6 35.6	17 24 32.29	− 6 22 48.2	9.211	0.819
19	10 4 59	14	7	+3 49.51	− 7 32.0	17 24 13.55	− 6 36 55.6	8.775	0.813
23	9 44 24	15	7	+2 53.19	+ 3 27.1	17 23 14.09	− 7 36 14.6	8.497	0.830
28	9 53 54	16	6	+2 57.25	− 7 6.6	17 22 42.78	− 8 51 15.8	8.991	0.836
Aug. 2	9 58 32	17	8	−0 31.40	−11 29.6	17 23 1.22	−10 5 57.3	9.185	0.841
5	8 53 2	18	7	−1 55.88	+ 3 55.2	17 23 35.34	−10 49 33.2	8.705	0.848
7	9 4 22	19	5	−2 52.80	− 7 57.7	17 24 8.32	−11 18 53.1	8.943	0.849
14	9 31 54	20	7	+1 27.51	− 3 17.7	17 26 1.20	−12 59 9.7	9.330	0.850
15	9 43 25	21	7	+0 38.85	+11 25.3	17 27 36.83	−13 13 1.6	9.325	0.852
16	8 47 14	21	4	+1 12.18	− 1 51.7	17 28 10.15	−13 26 18.7	9.063	0.861
19	9 53 4	22	8	−1 9.38	+ 6 31.1	17 30 5.77	−14 7 42.4	9.399	0.851
25	8 38 8	23	5	+3 3.07	− 5 11.2	17 34 40.59	−15 25 15.6	9.187	0.878
	9 0 0	24	5	+3 3.48	+ 5 5.6	17 34 41.28	−15 25 26.7	9.287	0.864
Sept. 1	7 59 17	25	8	+2 59.83	− 1 9.4	17 41 17.50	−16 50 15.4	9.080	0.877
	8 22 37	26	6 , 2	−1 5.10	− 2 55.7	17 41 18.59	−16 50 25.0	9.216	0.873
2	8 42 28	27	6	−2 31.04	+11 26.5	17 42 22.50	−17 2 14.1	9.311	0.869
3	7 47 9	27	7	−1 28.70	+ 0 24.2	17 43 21.83	−17 13 16.4	9.048	0.875

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	18 6 21.47	+2.04	+ 0 47 20.0	−15.1	Prof. Boss, 2 observations
2	18 6 9.68	+2.14	+ 1 5 44.9	−14.7	Boss, Albany Astr. Ges. Catal. 6135
3	18 6 4.18	+2.14	+ 1 7 27.4	−14.7	" " " " " 6134
4	18 4 18.58	+2.17	+ 1 6 46.3	−14.3	" " " " " 6115
5	18 1 18.09	+2.51	+ 1 34 38.4	−12.7	" " " " " 6086
6	18 0 54.22	+2.54	+ 1 31 27.3	−12.5	" " " " " 6083
7	18 0 10.49	+2.69	+ 1 24 42.6	−11.7	" " " " " 6073
8	17 56 25.57	+2.75	+ 1 18 28.3	−11.4	F.68 *Ophiuchi*
9	17 50 57.38	+2.92	+ 0 41 10.7	−10.2	Brussels, Glasgow I, Greenwich 1880
10	17 47 28.95	+2.99	− 0 0 45.4	− 9.5	Stone, Copeland and Borgen
11	17 38 33.69	+3.13	− 1 45 32.3	− 8.6	Armagh II. Stone
12	17 31 50.81	+3.15	− 2 48 42.9	− 8.5	Armagh II, Karlsruhe, Stone
13	17 21 55.63	+3.20	− 6 0 7.6	− 8.0	Yarnall, Munich I
14	17 20 20.81	+3.20	− 6 29 15.5	− 8.2	Stone, Vienna A.G.
15	17 20 17.68	+3.22	− 7 39 33.4	− 8.3	Vienna A.G.
16	17 19 12.34	+3.19	− 8 44 0.9	− 8.3	Gould, Gen. Catal., Stone, Vienna Astr. Ges.
17	17 23 29.41	+3.21	− 9 54 19.6	− 8.1	Brussels, Romberg, Stone
18	17 25 27.93	+3.22	−10 53 20.2	− 8.2	Stone, Brussels
19	17 26 57.90	+3.22	−11 10 47.1	− 8.3	Weisse-Bessel
20	17 25 33.53	+3.17	−12 55 43.6	− 8.4	Munich I, Munich II
21	17 26 54.81	+3.16	−13 24 18.5	− 8.4	Stone 4564
22	17 31 11.98	+3.17	−14 14 5.1	− 8.4	Brussels 7065
23	17 31 31.41	+3.11	−15 19 55.9	− 8.5	ξ *Serpentis*, Berlin *Jahrbuch*
24	17 31 31.71	+3.09	−15 30 23.7	− 8.6	Gould G.C., Stone, Greenwich
25	17 38 14.57	+3.10	−16 18 57.18	− 8.8	Stone 4617
26	17 42 20.57	+3.12	−16 47 21.0	− 8.3	Argelander, Bonn VI
27	17 44 50.11	+3.13	−17 13 32.2	− 8.4	Yarnall, Stone 4646

OBSERVATIONS OF MINOR PLANET (346),

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

BY ARTHUR J. ROY.

1895 Albany M.T.		*	No. Comp.	Planet — * $\Delta\alpha$	Planet — * $\Delta\delta$	Planet's apparent α	Planet's apparent δ	$\log p\Delta$ for α	$\log p\Delta$ for δ
	h m s			m s	′ ″	h m s	° ′ ″		
April 21	11 31 54	43	10	−0 3.32	− 6 53.6	15 55 51.49	−11 45 24.7	n9.416	0.840
23	12 33 57	43	7	−1 21.86	− 3 7.2	51 32.98	−11 41 38.2	n9.141	0.851
28	10 48 10	44	6	+3 49.08	− 1 11.1	51 5.66	−11 32 39.2	n9.445	0.836
May 1	14 19 39	44	8	+1 24.68	+ 4 23.3	48 41.33	−11 27 4.9	9.129	0.850
18	11 5 30	45	8	−2 0.89	− 4 6.8	34 16.20	−11 2 27.0	n8.911	0.850
22	11 37 33	46	6	+0 39.10	+ 1 24.0	30 43.37	−10 58 44.8	8.239	0.851
23	11 32 16	46	10	−0 12.98	+ 2 9.6	29 51.30	−10 57 59.1	8.216	0.851
24	10 58 22	47	6	+3 3.60	− 3 58.0	29 0.49	−10 57 21.3	n8.601	0.851
29	11 56 34	47	5	−1 11.61	− 1 42.6	24 45.33	−10 55 5.9	9.070	0.848
June 17	9 44 59	48	7	+2 8.20	− 3 5.3	11 51.61	−11 6 46.3	8.528	0.852
18	9 56 23	48	6	+1 37.80	− 4 38.9	11 21.21	−11 8 19.9	8.807	0.851
July 11	9 48 33	49	5	−1 1.19	−10 19.6	5 57.10	−12 10 3.3	9.352	0.846
18	9 27 12	50	10	+1 10.88	+ 2 5.4	6 40.91	−12 37 31.9	9.370	0.847
19	9 21 32	50	8	+1 22.37	− 2 7.7	6 52.40	−12 41 45.0	9.364	0.848
Aug. 13	8 43 47	51	10	+1 0.71	+ 0 37.9	18 13.33	−14 45 9.8	9.491	0.843
14	8 54 32	51	10	+1 42.70	− 4 52.3	15 18 55.31	−14 50 40.0	9.518	0.839

Mean Places for 1895.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
43	15 55 52.55	+2.26 +2.29	−11 38 14.4	−16.7 −16.6	Albany, 3 observations
44	17 14.18	+2.40 +2.47	−11 31 11.4	−16.7 −16.8	Albany, 1 observation
45	36 14.41	+2.68	−10 58 3.4	−16.8	Albany, 2 observations
46	30 1.58	+2.70	−10 59 52.1	−16.7	Albany, 2 observations
47	25 54.18	+2.76	−10 53 6.6	−16.7	Albany, 1 observation
48	9 40.68	+2.73	−11 3 24.7	−16.3	Albany, 2 observations
49	6 55.96	+2.63	−11 59 27.9	−15.8	Albany, 2 observations
50	5 27.47	+2.56	−12 39 21.7	−15.6	Gould, G.C. 20590; Stone 3917
51	15 17 10.27	+2.35	−14 45 32.7	−15.0	Greenwich 1880, etc. (F.30 *Librae*)

Star 51, adopted p.m. $-0^s.0025$, $+0''.013$. Comparisons of June 17 and 18 were made by Mr. J. H. OGBURN.

DETERMINATION OF THE EFFECT OF MAGNITUDE UPON TRANSITS,

BY R. H. TUCKER.

A preliminary determination of the variation in the chronographic record of transit, depending upon the brightness of the star, has been made by the use of a screen held in front of the object-glass. The screen is composed of four thicknesses of wire netting, and reduces the brightness of a star by 4.1 magnitudes, as determined by the estimated reduced magnitude, compared with that of the catalogue.

Twenty-two stars have been used, one-half of the list being screened on one night, and the remaining half on the succeeding night; alternate stars being observed in full and reduced brightness.

The clock-correction being determined from each set of eleven stars, the comparison of the differences between the two sets, upon two nights, gives a determination of the effect of magnitude, which will be independent of the systematic difference between the right-ascensions of the two sets. The whole list has also been observed in full brightness, to furnish a further check upon this systematic difference. The bisection in zenith-distance has always been made, in order that the observation should in all respects be similar to the usual one.

Miss JANE TUCKER has given volunteer assistance in screening the stars.

The effect upon the observed right-ascensions of the screen-reduction of 4.1 magnitudes is found to be $+0^s.037$; that is, faint stars are observed too late.

The probable error of a determination from one star, upon two nights, is $\pm 0^s.021$.

Thus, the correction to observed right-ascensions would be $-0^s.009$ for each magnitude; with a probable error of $\pm 0^s.001$.

Lick Observatory.

RELATIVE POSITIONS OF *DIONE* AND *RHEA*,

OBSERVED WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY ORMOND STONE.

The angles here given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction.

1894	Eastern Time	p	Eastern Time	s
	h m s	°	h m s	″
Mar. 14	13 38 2	320.99	. . .	. .
	13 43 55	322.42	. . .	. .
19	15 22 50	53.99	16 15 4	15.96
	. . .	. .	16 20 31	16.02
	. . .	. .	16 24 37	16.06
	. . .	. .	16 31 18	16.41
21	14 54 45	186.95	12 19 52	30.21
	12 53 5	202.69	12 25 24	29.91
23	12 25 29	62.94	12 32 29	64.86
26	11 26 39	245.85	. . .	. .
27	10 6 5	269.75	10 25 41	81.87
Apr. 2	11 47 18	75.65	. . .	. .
6	9 19 5	78.63	9 35 3	107.06
	10 45 19	80.03	11 3 17	112.67
8	10 27 44	260.03	10 47 32	38.84
	11 10 6	261.01	. . .	. .
14	13 14 8	24.55	13 36 48	22.26
	. . .	. .	14 8 53	23.89
16	15 24 52	87.90	15 45 37	49.94
	. . .	. .	15 48 14	49.98
22	13 1 7	269.14	13 46 13	31.14
	. . .	. .	13 47 41	31.49
24	11 24 32	350.59	11 30 34	20.43
	11 38 2	354.39	11 34 54	20.79
27	8 38 35	272.11	8 46 5	122.57
	8 55 53	272.26	8 48 0	121.89
28	8 51 18	64.97	8 58 50	44.73
	9 5 58	65.65	9 0 6	45.00
	9 9 17	65.84	. . .	. .
29	14 8 20	93.17	14 17 19	26.19
	14 26 50	93.37	14 18 58	26.16
	15 0 32	93.95	15 10 18	25.72
	15 18 49	93.72	15 12 22	25.39
30	13 5 51	94.17	13 13 25	44.55
	13 21 27	94.65	13 15 28	44.59

1894-95	Eastern Time	p	Eastern Time	s
	h m s	°	h m s	″
May 1	8 28 1	204.15	8 35 24	21.69
	8 42 53	207.67	8 37 31	21.89
3	8 47 0	65.43	8 52 37	70.27
	9 0 35	66.25	8 54 5	70.53
8	9 49 32	68.08	9 59 9	52.77
	10 7 55	69.42	10 1 52	52.85
20	10 42 10	291.42	10 48 54	12.59
	11 0 16	291.34	10 53 54	12.56
June 3	9 31 25	2.48	9 36 17	5.36
	9 41 38	0.95	9 38 9	5.41
	9 44 35	0.59	. . .	. .
4	9 29 12	49.22	9 35 48	17.10
	9 48 23	51.43	9 45 30	17.53
13	9 9 3	75.71	9 15 53	91.12
	9 24 54	75.95	9 18 13	91.42
15	10 12 34	262.27	10 33 21	99.67
	10 42 4	262.86	10 35 37	99.31
1895				
Apr. 5	12 29 48	229.74	12 41 11	16.22
	12 35 28	231.22	12 45 26	16.34
	12 59 8	232.09	12 49 28	16.46
	13 3 56	230.93	12 52 18	16.60
	15 20 56	238.71	. . .	. .
	15 40 18	239.27	. . .	. .
	15 45 6	238.83	. . .	. .
11	13 28 7	70.11	13 39 34	26.74
	13 59 17	70.42	13 44 39	26.66
13	14 26 36	101.97	15 11 7	77.00
	15 26 52	103.64	15 15 37	76.48
	. . .	. .	15 17 17	76.65
May 18	10 7 28	56.43	10 13 0	47.46
	10 33 5	58.50	10 16 51	48.05
	. . .	. .	10 25 56	49.22
22	11 38 13	82.63	11 53 33	70.57
	11 42 41	82.80	11 55 13	70.34
	12 9 35	83.34	11 58 44	70.35
	12 14 7	83.32	12 0 10	70.50
June 2	11 41 45	145.42	. . .	. .
	12 21 45	152.80	. . .	. .

NOTICE.

A few copies of the *Astronomische Nachrichten*, vols. 100 to 141, inclusive, may be obtained for $75.00 the set, on application to the Editor of this Journal, at Cambridge. The regular price is very much higher.

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Published in Boston, tri-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed July 20.*

THE
ASTRONOMICAL JOURNAL.
No. 381.

VOL. XVI. BOSTON, 1896 AUGUST 7. NO. 21

THE SECULAR PERTURBATIONS OF *MERCURY* ARISING FROM THE ACTION OF *MARS*,

By ERIC DOOLITTLE.

The following computation has been made according to Dr. G. W. HILL's first modification of GAUSS's method, which has been described in the article on the Secular Perturbations of *Mercury* Arising from the Action of the Earth (*Astronomical Journal*, no. 376).

The elements which were adopted are from Dr. HILL's "*New Theory of Jupiter and Saturn.*"

Mercury.	*Mars.*
$\pi = 75^\circ\ 7'\ 13''.62$	$\pi' = 333^\circ\ 17'\ 51''.74$
$i = 7\ \ 0\ \ 7.71$	$i' = 1\ \ 51\ \ 2.24$
$\Omega = 46\ \ 33\ \ 8.63$	$\Omega' = 48\ \ 23\ \ 54.59$
$e = 0.20560476$	$e' = 0.09326803$
$n = 5381016''.260$	$n' = 689050''.784$
$\log a = 9.5878217$	$\log a' = 0.1828971$
$m = \frac{1}{5,000,000}$	$m' = \frac{1}{3,093,500}$

Epoch, 1850.0 Greenwich Mean Time.

The following are the values of the preliminary constants:

$I = 5^\circ\ 9'\ 10''.18$	$\log k = 9.9983990$
$\pi = 209\ \ 13\ \ 54.31$	$\log k' = 9.9998432$
$\pi' = 107\ \ 24\ \ 19.30$	$c = 0.02019574$
$K = 101\ \ 45\ \ 36.16$	$\log c = 8.3052598$
$K' = 101\ \ 53\ \ 33.05$	

The circumference of *Mercury's* orbit was at first divided into twelve parts with regard to the eccentric anomaly. The tests furnished by comparing the sums of the functions corresponding to the odd and even points of division were not satisfied; the sums for ϵ differing by 40′ 42″.47, and for θ by 1° 38′ 46″.90. Dr. HILL kindly verified the values of ϵ, and suggested that the number of points of division be increased to twenty-four. This diminished the disagreement about three-fourths in the first part of the computation, while with $\log P$, $\log Q$, $\log V$ and the remaining functions, the test was satisfied very exactly.

The first part of the work was verified by the following equations:

$$\Sigma(A) = 6a^2 + 3a^2e^2 + 6\left[a'^2 - 2kaa'ee'\cos K\right];$$
$$\Sigma(B\cos\epsilon) = 6\left[a'^2e' - kaa'e\cos K\right];$$
$$\Sigma(B\sin\epsilon) = -6\left[k'aa'\cos q'e\sin K'\right];$$
$$G + G' - G'' = A - C \quad ; \quad GG'G'' = g$$

The computation was carried twice through from the begining at different times as a further check.

The following values were obtained for the differential coefficients:

	log coeff.
$\left[\frac{de}{dt}\right]_{00} = -\ 1879.077\,m'$	$3.2739145\,n$ $[3.2739446\,n]$
$\left[\frac{d\chi}{dt}\right]_{00} = +\ 76914''.75\ m'$	$4.8860096\,p$ $[4.8860096\,p]$
$\left[\frac{di}{dt}\right]_{00} = -\ \ 934''.067\,m'$	$2.9703779\,n$ $[2.9703782\,n]$
$\left[\frac{d\Omega}{dt}\right]_{00} = -\ 59594''.26\ m'$	$4.7752044\,n$ $[4.7752043\,n]$
$\left[\frac{d\pi}{dt}\right]_{00} = +\ 76470''.27\ m'$	$4.8834926\,p$ $[4.8834926\,p]$
$\left[\frac{dL}{dt}\right]_{00} = -101879''.0\ m'$	$5.0080846\,n$ $[5.0080846\,n]$

The quantities in brackets are the logarithms which were obtained when the orbit was divided into twelve parts. It is thus evident that the want of agreement in ϵ is of no consequence.

Adopting the above value of m', we have the following results:

$$\left[\frac{de}{dt}\right]_{00} = -0.000\,607\,428$$
$$\left[\frac{d\chi}{dt}\right]_{00} = +0.024\,863\,343$$
$$\left[\frac{di}{dt}\right]_{00} = -0.000\,301\,945$$
$$\left[\frac{d\Omega}{dt}\right]_{00} = -0.019\,264\,347$$
$$\left[\frac{d\pi}{dt}\right]_{00} = +0.024\,719\,659$$
$$\left[\frac{dL}{dt}\right]_{00} = -0.032\,933\,242$$

The values of these coefficients, derived from slightly different elements, were stated by LeVerrier (*Annales de l'Observatoire de Paris, Mémoires*, Tome V, pp 6, 7, 21). Adopting LeVerrier's mass of *Mars*, the following is a comparison of the results obtained by the two methods:

Method of Gauss. Method of LeVerrier.

$$\left[\frac{de}{dt}\right]_{00} = -0.000\,627 \qquad -0.000\,62$$

$$\left[\frac{di}{dt}\right]_{00} = -0.000\,312 \qquad -0.000\,31$$

$$\left[\frac{d\Omega}{dt}\right]_{00} = -0.019\,898 \qquad -0.019\,83$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +0.025\,531 \qquad +0.025\,5$$

$$\left[\frac{dL}{dt}\right]_{00} = -0.034\,017 \qquad -0.034\,1$$

University of Chicago, 1896 *June* 27.

DISCORDANCES IN D'AGELET'S OBSERVATIONS.

(Communication from Mr. A. Gaillot.)

In the published Reduction of d'Agelet's observations, made at the Military School of Paris, in the years 1783–1785, the resultant Catalogue contains 6497 determinations of positions for 2907 stars. Upon page 32 is given a list of 16 stars which I had not succeeded in identifying satisfactorily, or for which the discordances appeared too large to be easily disposed of by any conjecture similar to those which had been abundantly made throughout the work.

One of these (no. 3171) was disposed of, nevertheless, in the Corrigenda given upon the last page of the memoir. But to the list another star (nos. 5057–59) was subsequently added which, owing to the existence of accordant observations on three nights, had not appeared suspicious, yet was found not to exist in the sky when opportunity for verification was subsequently obtained.

In no. 1615 of the *Astronomische Nachrichten* (vol. 69, p. 201), is a list of eleven of these supposed stars, sent me by Prof. Schönfeld, who, with his characteristic thoroughness and skill, had discovered the explanation of the erroneous record. The catalogue-places deduced by means of the corresponding corrections are there given. The stars nos. 1615 and 4604 were moreover found to have been observed by Bessel and in Argelander's *Durchmusterung* respectively.

In December last, Mr. Gaillot of the Paris Observatory kindly sent me the probable explanation of many of these cases. But having seen, soon afterwards, the results of Schönfeld's investigation, just cited and with which his own are in perfect accord, he found another observation to be capable of explanation; namely, no. 1893.

Mr. Gaillot writes, after study of the originals preserved in the archives at Paris, denoting by A the reading from the graduation of the quadrant into 90°, and by B that from the system of 96 divisions (see "Reduction," pp. 5, 6). He says of the observation of this star, 1783 Feb. 26:

"On the record: original zenith-distance $A = 26° 41' 26''$. The degrees have been corrected, and 24° substituted. Zenith-distance $B = 24° 13' 9'' 1$. This latter is identically the same as that written in the record of the preceding observation.

"In the *Histoire Céleste*, the reading B was suppressed for the first star, and the reading A for the second. The reading B ought also to have been suppressed for the second, and the uncorrected reading A to have been printed in its place. The star observed is 20 *Leonis*.

"I have carefully examined the observations corresponding to nos. 5593, 5594 and 6052.

"For 5593, this is what I have found. D'Agelet did not observe any right-ascension; he simply recorded '6 mag. at 22½',' and the proof that this was not the observation of the transit across a thread is that d'Agelet, who always supplies the place of a missing thread by a dash (—) put nothing here. In the memoir of the Academy, 22m 30s was printed for the middle thread, which I consider as entirely arbitrary. In my belief, the star is certainly 31 *Vulpeculae*, the right-ascension of which differs but little from the mean of the right-ascensions of the preceding and following star, while there are only 52s between the last thread of the former (ω *Capricorni*) and the recorded middle thread of the observation in question, with a difference of nearly 60° in the zenith-distance.

"No. 5594 ought, I think, to be suppressed, purely and simply. It corresponds to one of the latest observations of a short series which d'Agelet ends by writing the note: '*Belle nuit, j'ai eu des fluxions qui m'ont empêché d'observer.*' It should be added that, as you have remarked, the threads are not accordant, and that the minute for the first has been corrected.

"Regarding no. 6052 I have found nothing particular. The observation does not appear to me to be affected by any error. Is it a planet or a variable?

"The three observations of no. 5057–59 are still more assuredly very exact. On each of the dates d'Agelet observed the transit on all three threads, and the zenith-distance on both divisions of the quadrant. It is certainly a new star, the light of which has become imperceptible."

The list of unrecognized stars in d'Agelet's observations is thus exhausted; and only two of them remain so enigmatic as to demand future research. These are

Nos.	Mag.	α 1800 h m s	δ 1800 ° ′ ″	Date of obs.
5057–59	6	19 23 17.6	+17 19 42.8	1783 July 26, 27, 29
6052	7·8	22 9 8.5	+25 21 57.3	1783 Sept. 15

It is needless to say that both of them have been repeatedly looked for in the sky without success.

G.

OBSERVATIONS OF SUSPECTED VARIABLES,

By J. A. PARKHURST.

Espin 832. R.A. = $0^{h}\,16^{m}.8$, Decl. = +58° 36′, 1900.

The place of this suspect, as given in *A.N.* No. 3232, was examined on the following dates: 1894 Dec. 14, 20; 1895 Jan. 1, 24, Feb. 19, March 18, May 26, July 24, Sept. 30, Dec. 25; 1896 June 10. A $12^{M}.5$ star was found near the indicated place, but no change was noticed in it or the neighboring 11^{M} and 12^{M} stars.

(1804), DM. 3°764. R.A. = $4^{h}\,58^{m}\,14^{s}.9$, Decl. = +3° 50′.3, 1855.

The variability of this comparison-star for 1805 *V Orionis* was suspected by Yendell (*A.J.* 367). I have used it as a comparison-star on 22 dates, between 1894 Feb. 19 and 1896 April 3, without noticing any considerable fluctuation. My estimation of its magnitude from all comparisons is $10^{M}.2$, with an extreme range from $9^{M}.7$ (poor seeing) to $10^{M}.3$.

(1078), DM. 59°594. R.A. = $2^{h}\,59^{m}.7$, Decl. = +60° 6′, 1900.

The variability of this star was suspected by Espin (*A.N.* 3232), it being found by him $8^{M}.6$ 1893 Dec. 1, while the DM. magnitude is 9.5. I have 13 observations between 1894 Dec. 14 and 1896 June 30. The extreme magnitudes found were $8^{M}.3$ and $8^{M}.8$, the last-named magnitude being found only once, on the last date, in poor seeing. No proof of variability can be deduced from these observations.

Espin-Birm. 735, DM. 54°2863.
R.A. = $22^{h}\,43^{m}.6$, Decl. = +54° 38′, 1900.

This star has been watched since 1894 Dec. 14. It was then $7^{M}.8$. It fell slowly and irregularly to a minimum, $8^{M}.6$, about 1895 Sept. 1. It was $7^{M}.5$ at the last observation, 1896 July 11. I have 17 observations between the above dates, not enough to determine the character of the light-curve. The magnitudes are based upon Rogers's values, in the *Astr. Ges. Catal.*, of the following comparison-stars:

DM.	M
54°2867	7.2
53°2987	7.5
54°2854	8.8
54°2865	8.9
54°2864	9.0

Marengo, Ill., 1896 *July* 20.

THE ELIMINATION OF POSITION-ERROR IN THE OBSERVATION OF VARIABLE-STARS,

By ALEXANDER W. ROBERTS.

Recently there have been two references to the influence of relative position upon the apparent magnitudes of two or more stars.

Prof. Barnard, in *A.J.* no. 370, deals with the apparent variation in the light of the satellites *Oberon* and *Titania*, remarking (p. 75), "It would appear that the apparent variation of light is probably due to a physiological effect, and that the eye has a tendency to make the lower of two equal lights appear the brighter by about ½ magnitude."

Dr. Chandler, in *A.J.* no. 374 (p. 107), points out that the "systematic effect arising from unequal sensitiveness of different portions of the retina, dependent on varying positions of the variable, relative to its comparison-stars, in different hour-angles," influences the times of minimum phase of *U Pegasi* to an appreciable and easily measurable extent.

There is, perhaps, no careful observer but is fully cognizant of the influence of this tendency; and each observer, no doubt, adopts some precaution to guard against his results being vitiated by it. A natural precaution would be to observe, when possible, the same stars at the same hour-angle. This is not, however, always practicable. Dr. Chandler urges that the observer's head should be kept in the same relative position with reference to the comparison-stars. This method also is not always possible.

I mention again, to bring before variable-star observers, a method of observation that I have found of service in dealing with the difficulty. All stars fainter than 5^{M} I observe twice; first, with a direct-vision eye-piece, then immediately after with an ordinary astronomical reversing eye-piece. Both observations are inserted side by side in the observing book; the mean of both is the observation entered in the ledger. There is, no doubt, double labor in such a method; but the need of taking precautions concerning position of the head, or position of the comparison-stars, is done away with. And yet there is care needed, for as a rule the direct-vision eye-piece is considerably longer than the reversing eye-piece, and so if the telescope be not heightened proportionately each time the longer eye-piece is used, there is danger of the position of the head being different at the two observations, and thus error of a systematic nature will soon make itself evident.

There is another advantage in this method. The double observation to some extent prevents bias, as the observer forgets the previous observation when he is taking one quite different. In my own experience I found that, after the introduction of double observations, the mean error fell from $0^M.12$ and $0^M.13$ to about $0^M.05$.

A still more accurate method of eliminating the position-error would be to have a prism mounted behind the eye-piece, so that the variable and its comparison-stars could be rotated 90° at each observation. There would be thus four observations instead of two; the mean of the four observations being recorded in the ledger as the magnitudes of the variable and its comparison-stars.

I am certain that when the magnitudes thus obtained were reduced to standard values, it would be found that the mean error of an observation — using the word observation here to designate the mean of the four — would not be greater than $0^M.03$.

I trust shortly to introduce this method into the variable star work here.

This is not the place nor the time to deal with the amount, nature, and cause of this variation. At present it will suffice to state that if the differences between the direct observations and the reverse observations of the same star be tabulated, the systematic differences will be fairly well represented by an expression of the form,

$$m\cos(\odot - M) + n\cos(2\odot - N).$$

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

By J. A. PARKHURST.

1574. *W Tauri.*

My observations began 1895 Dec. 13, when the star was 12^M. It rose slowly to $9^M.2$ at the last comparison, 1896 April 21. These observations, 13 in number, do not locate definitely either the minimum or maximum, but the probability seems to be that the minimum occurred in December; and as the rise during the last month of observation was hardly noticeable, it seems that the maximum was passed in April. The position of *W* relative to *θ′ Tauri* was measured on two nights, with the result

$$\text{R.A.} = 4^{h}\,19^{m}\,41^{s}.0 \quad \text{Decl.} = +15^{\circ}\,42'\,53'',\quad 1855$$
$$4\;\;22\;\;14.7 \qquad\qquad +15\;\;49\;\;11,\quad 1900$$

1805. *V Orionis.*

This star could not be seen 1895 Dec. 9, the limit being 12^M. It was caught 1896 Jan. 6, and followed till lost in the western twilight, being last seen April 21. The rise was rather rapid from $11^M.6$ at the first observation, to $9^M.3$ March 11, then more gradual to $8^M.8$ when last seen. It was impossible, on account of the unfavorable position of the star, to tell whether the maximum was then past or not. I have 13 observations between the above-mentioned dates.

2100. *U Orionis.*

From 13 observations, between 1896 Jan. 6 and April 30, I find a maximum, $6^M.25$ March 26. The form of the light-curve was similar to those of the last two maxima.

2258. *V Aurigae.*

I have 12 observations of this star between 1896 Jan. 6 and June 10. It fell slowly from $11^M.2$ at the first date, to a minimum, $11^M.6$, Feb. 10, then rose irregularly to 10^M at the last comparison. The extreme red color of the star near minimum rendered the observations somewhat uncertain. The interval since my last observed minimum is 330 days, the preceding interval having been 335 days.

3264. *W Cancri.*

This star decreased from $9^M.9$, 1896 April 3, to $11^M.2$ May 9. Besides 5 observations for magnitude between the above dates, I measured its position relative to DM. 25°2059, with the following results:

$$\text{R.A.} = 9^{h}\,1^{m}\,23^{s}.9 \quad \text{Decl.} = +25^{\circ}\,50'\;\;9'',\quad 1855$$
$$9\;\;4\;\;\;2.3 \qquad\qquad +25\;\;39\;\;18,\quad 1900$$

6446. *T Draconis.*

This star has been followed closely since the last minimum, 40 observations being made between 1895 Aug. 8 and 1896 July 6. It rose quickly from minimum to $10^M.2$, which was reached about Sept. 10. During the rest of September and October it rose slowly to $9^M.7$, then more quickly to 8^M about 1896 Jan. 15. From this time till April 15 the change noticed was very slight, but the low altitude of the star, from 10° to 15°, made the estimates uncertain. During May and June the fall was quite rapid, $9^M.5$ being reached at the last observation. The curve gives a maximum, $7^M.95$, 1896 March 6.

8324. *V Cassiopeae.*

A continuous watch is being kept on this star, 14 observations since the last minimum yielding a maximum, $7^M.3$, 1896 June 5. At the last comparison, July 16, it had fallen to $9^M.0$. This maximum gives a correction to the ephemeris founded on my elements (*A.J.* 358) of −2 days. The correction from CHANDLER's elements (Third Catalogue) is +4 days.

Marengo, Ill., 1896 *July* 18.

OBSERVATIONS OF COMET c 1896 (1889 V),

MADE AT THE LICK OBSERVATORY,

BY WILLIAM J. HUSSEY.

1896 Mt. Hamilton M.T.	*	No. Comp.	☄ − * $\Delta\alpha$	☄ − * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
d h m s			m s	′ ″	h m s	° ′ ″		
July 8 15 2 1	1	d10 , 5	−0 2.10	−3 5.2	22 36 40.56	−18 12 13.5	n8.813	0.860
9 14 10 50	4	d12 , 5	+0 2.60	−1 31.8	22 37 1.49	−18 12 8.7	n9.201	0.856
10 14 42 50	2	4	. . .	−3 47.5	. . .	−18 12 6.7	. .	0.850
15 5 44	2	17	−0 54.07	. . .	22 37 22.63	. . .	n9.190	. .
11 12 47 43	2	d10 , 11	−0 37.37	−3 46.7	22 37 39.36	−18 12 5.8	n9.465	0.836
12 12 51 24	2	d 9 , 10	−0 20.45	−4 1.1	22 37 56.31	−18 12 20.1	n9.452	0.837
13 12 47 31	2	5	. . .	−4 11.3	. . .	−18 12 33.3	. .	0.837
15 13 55 26	5	3	. . .	−1 9.2	. . .	−18 13 29.1	. .	0.856
14 50 52	5	d 6	−0 3.96	. . .	22 38 37.94	. . .	n8.415	. .
16 13 59 11	5	d, 5 , 5	+0 5.91	−1 11.7	22 38 17.83	−18 14 4.5	n9.107	0.857
17 14 29 20	5	d 5 , 5	+0 14.52	−2 26.2	22 38 56.46	−18 14 15.9	n8.690	0.862

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 36 39.34	+3.32	−18 9 26.8	+18.5	12ᴹ ±. Connected with *2
2	22 38 13.31	. .	−18 8 38.0	. .	S.DM. −18°6168. Connected with *3
3	22 38 17.33	+3.36	−18 3 55.5	+18.6	Weisse's Argelander 17560
4	22 36 55.53	+3.36	−18 10 55.5	+18.6	12ᴹ ±. Connected with *2
5	22 38 38.38	. .	−18 12 39.1	. .	10ᴹ ±. Connected with *2

The observations of July 11, 12 and 13 were made with the 12-inch, and the others with the 36-inch telescope. d indicates that $\Delta\alpha$ was measured directly with the micrometer. For *2 the reductions to apparent place are for July 10, +3ˢ.39, +18″.8; July 11, +3ˢ.42, +18″.9; July 12, +3ˢ.45, +19″.0; July 13, +3ˢ.47, +19″.0; and for *5, July 15, +3ˢ.52, +19″.2; July 16, +3ˢ.54, +19″.3, and July 17, +3ˢ.56, +19″.4.

Mt. Hamilton, Cal., 1896 *July* 18.

MERIDIAN-CIRCLE OBSERVATIONS OF COMPARISON-STARS FOR COMET c 1895,

BY R. H. TUCKER.

The following list of stars, observed with the meridian circle, were used by Mr. PERRINE in his observations of Comet c 1895, one extra star being included. The places are published now, in order that they may be available if needed by other observers.

The discordance between the observed places and those given in Weisse's BESSEL and Munich I. are in some cases large enough to show the evident need of a new determination.

Mag.	R.A. 1896.0	Decl. 1896.0
	h m s	° ′ ″
8¾	19 17 45.83	+16 8 11.2
9	19 18 59.73	+15 33 29.2
8½	19 19 20.67	+15 31 38.0
9¼	19 38 48.44	− 5 2 19.2
7	19 39 40.30	+ 8 28 38.7
8¾	19 41 31.97	− 2 31 29.7
9	19 43 41.72	− 6 17 14.9
8¾	19 45 18.43	+ 0 27 12.0
8	19 46 39.20	− 2 25 9.0
8¾	19 46 58.03	− 1 32 18.4

Mt. Hamilton, 1896 *July* 9.

It should be noted, in connection with the observed places of faint stars, that there appears to be a correction to transits depending upon the magnitude. This has been determined by screen-transits of bright stars; and later and more complete observations than those already published (*A.J.* no. 380), give consistently the same result, a correction of −0ˢ.009 per magnitude for the observed right-ascension of fainter stars.

Since the places of the stars in this list were reduced by means of Berlin *Jahrbuch* stars of 3½ᴹ the average correction would be nearly −0ˢ.05.

Such corrections, however, will be needed, in general, only in more refined classes of observation; and their application may well wait the concerted judgement and action of astronomers.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER AT GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY H. C. WILSON.

[Communicated by the Director, W. W. PAYNE.]

1896 Northfield M.T.		*	No. Comp.	☌ − *		☌'s apparent		log *p*Δ	
				Δα	Δδ	α	δ	for α	for δ
	COMET *c* 1895 (PERRINE).								
	h m s			m s	′ ″	h m s	° ′ ″		
Feb. 18	17 19 37	1	9 , 4	+0 41.61	+0 35.1	. .	. .	. .	. .
	17 19 37	2	9 , 4	−0 16.12	1 13.4	19 45 55.16	− 0 55 26.0	*n*9.563	0.701
	COMET *a* 1896 (PERRINE-LAMP).								
Feb. 21	17 30 49	3	8 , 4	−1 20.66	−1 1.4	20 46 59.79	+24 30 8.3	*n*9.655	0.701
27	10 10 6	4	10 , 5	−1 2.05	−2 36.4	23 6 55.14	+46 50 11.4	9.576	0.896
	10 10 6	5	11 , 3	−1 36.83	−0 32.6	. .	. .	. .	. .
Mar. 7	8 8 41	6	9 , 6	+0 27.10	−0 25.1	2 14 58.74	+50 48 38.9	9.720	0.416
14	9 59 28	7	9 , 4	+1 25.43	+2 17.1	3 16 12.61	+47 36 11.6	9.795	0.652
19	9 34 29	8	9 , 3	+2 41.80	−4 30.8	3 40 5.35	+45 41 59.8	9.780	0.616
	9 34 29	9	9 , 4	+2 36.99	−0 51.7	3 40 5.62	+45 41 58.7	9.780	0.616
	COMET *b* 1896 (SWIFT).								
Apr. 18	8 37 16	10	3 , 2	−0 35.38	+9 20.1	3 36 57.07	+23 28 39.7	9.652	0.793
20	8 33 7	11	6 , 4	+3 58.43	+0 19.3	3 34 16.14	+28 53 12.4	9.669	0.790
21	8 34 27	12	6 , 4	−1 0.63	−0 12.8	3 32 25.79	+31 34 39.6	9.677	0.791
	8 34 27	13	6 , 4	−1 54.52	+4 59.6	3 32 25.45	+31 34 42.7	9.677	0.791
23	8 5 21	14	9 , 4	+0 30.72	+6 40.2	. .	. .	9.712	0.758
May 1	9 50 50	15	5 , 4	+3 28.85	+3 3.8	2 37 22.90	+58 35 1.3	9.581	0.902

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 45 14	−0.07	− 0 56	−11.8	Anonymous
2	19 46 11.35	−0.07	− 0 54 0.8	−11.8	Munich (1), 22014
3	20 48 21.13	−0.68	+24 31 21.0	−11.3	Armagh (2), 2725
4	23 7 58.70	−1.51	+46 52 16.2	+ 1.6	Argel. N. Zones 47, 119
5	23 8 34	. .	+46 51	. .	DM. 46°3974
6	2 14 32.19	−0.55	+50 48 47.7	+16.3	Bonn VI, 50°530
7	3 14 47.17	+0.01	+47 33 37.4	+17.2	Radcliffe (1), 933
8	3 37 23.38	+0.17	+45 46 14.0	+16.6	Deichmüller, Bonn A.G. Catal. 3125
9	3 37 28.46	+0.17	+45 42 33.8	+16.6	Deichmüller, Bonn A.G. Catal. 3126 (Pr. mot.
10	3 37 32.29	+0.16	+23 19 11.3	+ 8.3	Paris 4380 [+0s.03; −0″.07)
11	3 30 17.62	+0.09	+28 52 41.1	+ 9.0	Weisse's Bessel III, 586
12	3 33 26.35	+0.07	+31 35 13.0	+ 9.4	Leyden A.G.Z. 243, 127; 352, 42
13	3 34 19.90	+0.07	+31 29 33.6	+ 9.5	Leyden A.G.Z. 243, 128; 352, 43
14	3 27 13	−0.04	+36 39	+ 9.8	D.M. 36°724
15	2 33 55.01	−0.96	+58 31 50.5	+ 7.0	Radcliffe (1), 760

NOMENCLATURE OF ASTEROIDS.

The following names have been assigned by Prof. WOLF to small planets found by him:

(330) =	1892 *X*	1892 March 18	*Adalberta*	(351) =	1892 *V*	1892 Dec. 16	*Yrsa*
(341) =	1892 *J*	1892 Sept. 25	*California*	(385) =	*AX*	1894 March 1	*Ilmatar*
(342) =	1892 *K*	1892 Oct. 17	*Endymion*	(391) =	*BE*	1894 Nov. 1	*Ingeborg*
(343) =	1892 *N*	1892 Nov. 15	*Ostara*				

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE SAYRE OBSERVATORY, SO. BETHLEHEM, PA.,

BY JOHN H. OGBURN.

1895 Bethlehem M.T.	∗	No. Comp.	Planet — ∗ Δα	Planet — ∗ Δδ	Planet's apparent α	Planet's apparent δ	log pΔ for α	log pΔ for δ
				(24) Themis.				
	h m s		m s	′ ″	h m s	° ′ ″		
Oct. 11 10 5 45	1	9 , 4	−1 22.32	−0 21.4	1 47 30.52	+10 53 13.7	n9.401	0.685
14 10 7 35	2	10 , 5	−0 6.67	+9 14.9	1 45 11.90	+10 41 5.9	n9.358	0.685
15 10 1 16	2	7 , 4	−0 52.47	+5 9.86	1 44 29.11	+10 37 1.0	n9.363	0.684
21 9 54 18	3	6 , 4	−1 47.94	−7 42.7	1 39 50.95	+10 11 53.2	n9.289	0.682
				(313) Chaldaea.				
Oct. 23 9 33 35	4	9 , 4	+1 13.89	+5 31.8	1 10 45.26	−1 26 6.1	n9.213	0.786
24 9 28 14	4	13 , 7	+0 24.29	−3 27.8	1 9 55.67	−1 35 8.7	n9.216	0.787
				(241) Germania.				
Nov. 11 8 16 6	5	7 , 4	+3 28.15	−1 38.2	2 7 25.55	+19 49 52.0	n9.441	0.584
12 8 14 50	5	6	+2 44.59	−7 21.0	2 6 41.99	+19 44 9.3	n9.434	0.583
				(113) Amalthea.				
Dec. 6 8 11 53	6	4	−1 16.11	+4 56.4	5 40 7.71	+17 46 29.0	n9.622	0.689

Mean Places for 1895.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 48 48.88	+3.96	+10 53 8.3	+26.8	Weisse's Bessel
2	1 45 17.58	+4.00	+10 31 23.9	+27.2	Pulkowa 1855, Brussels, Greenwich
3	1 41 34.85	+4.04	+10 19 10.0	+25.9	Greenwich 1850, Yarnall
4	1 9 27.35	+4.02	− 1 32 7.7	+26.8	F.38 *Ceti*
5	2 3 53.09	+4.31	+19 51 2.0	+28.2	Paris 2668
6	5 41 18.76	+5.06	+17 41 21.9	+10.7	Romberg, Pulkowa 1855, Greenwich

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ELEMENTS AND EPHEMERIS OF MINOR PLANET (346),

BY ARTHUR J. ROY.

The following elements of minor planet (346) were derived from the April, June and August observations published in *A.J.* 380.

$$\text{Epoch} = \text{June } 18.5,\ 1895 \text{ Berlin M.T.}$$

$$M = 229^\circ\ 1'\ 18''.4$$

$$\left.\begin{aligned}\omega &= 287\ 14\ 43.0\\ \Omega &= 92\ 22\ 6.8\\ i &= 8\ 45\ 24.2\end{aligned}\right\}1895.0$$

$$\begin{aligned}\varphi &= 5\ 51\ 2.7\\ \mu &= 758''.9414\\ \log a &= 0.4465324\end{aligned}$$

The observed and computed positions compare as follows:

	O−C Δα	O−C Δδ
	s	″
April 21	−0.05	+0.3
23	+0.01	+1.2
28	−0.02	−0.1
May 1	+0.01	−1.5
May 18	0.00	−0.7
22	+0.08	−0.2
23	+0.15	+0.5
24	+0.08	−0.3
May 29	+0.18	−0.1
June 17	−0.03	−1.0
18	−0.05	−0.1
July 11	−0.28	+1.3
July 18	−0.16	+1.2
19	−0.19	+1.6
Aug. 13	−0.02	−0.1
14	0.00	+1.0

The comparison-star of June 17 and 18 was redetermined after the computations were made.

EPHEMERIS FOR BERLIN MEAN MIDNIGHT.

1896	App. α	App. δ	log Δ	Aberr. Time
	h m s	° ′ ″		m s
Aug. 10	22 41 5.75	−20 55 28.2	0.210140	13 28
11	40 25.29	−21 3 5.0	0.209151	26
12	39 43.85	10 59.9	0.208229	24
13	39 1.49	18 12.5	0.207372	22
14	38 18.26	−21 25 42.2	0.206583	13 21

1896	App. α	App. δ	log Δ	Aberr. Time
	h m s	° ' "		m s
Aug. 15	22 37 31.19	−21 33 8.5	0.205862	13 19
16	36 19.36	40 31.0	0.205210	18
17	36 3.82	47 19.4	0.204626	17
18	35 17.62	55 2.4	0.204112	16
19	34 30.81	−22 2 40.3	0.203668	16
20	33 43.45	9 12.4	0.203294	15
21	32 55.62	16 8.3	0.202990	15
22	32 7.36	22 57.5	0.202757	14
23	31 18.73	29 39.5	0.202595	14
24	30 29.79	36 13.9	0.202504	14
25	29 40.61	42 40.4	0.202484	14
26	28 51.26	48 58.4	0.202535	14
27	28 1.78	55 7.5	0.202658	14
28	27 12.25	−23 1 7.3	0.202851	14
29	26 22.74	6 57.5	0.203114	15
30	25 33.32	12 37.8	0.203448	15
31	24 44.01	−23 18 7.7	0.203852	13 15
Sept. 1	22 23 54.98	−23 23 26.8	0.204326	13 16
2	23 6.21	28 35.1	0.204868	16
3	22 17.78	33 31.9	0.205478	17
4	21 29.76	38 17.1	0.206156	19
5	20 42.22	42 50.5	0.206902	21
6	19 55.23	47 11.8	0.207713	23
7	19 8.86	51 20.8	0.208590	25
8	18 23.17	55 16.9	0.209531	27
9	17 38.25	59 0.3	0.210536	29
10	16 54.11	−23 2 30.8	0.211603	31
11	16 10.84	5 48.4	0.212730	33
12	15 28.50	8 52.5	0.213917	35
13	14 47.14	11 42.7	0.215162	37
14	14 6.82	14 20.6	0.216462	39
15	22 13 27.59	−24 16 45.5	0.217818	13 42

Magnitude at opposition, August 27, 10.6.

NEW ELEMENTS OF ASTEROID (387),

BY JOHN H. OGBURN.

This planet was discovered in March 1894. From May 1 to Sept. 3, during the summer of 1895, I observed it on every favorable night. Normal places were formed for May 1, July 3 and Sept. 1, each depending on four or more observations near the respective date. From these, assumed as correct, the following elements, to be afterwards corrected, were derived. They represent observations made in March 1894, to within a few seconds. An ephemeris for the approaching opposition in November will be published sometime during the summer.

Epoch: 1895 July 3.5 Berlin M.T.

$$\begin{aligned} M &= 353^\circ\ 6'\ 10''.16 \\ \omega &= 153\ 33\ 18.42 \\ \Omega &= 128\ 33\ 49.93 \\ i &= 17\ 57\ 56.96 \end{aligned} \Bigg\}\ \text{Mean Equin. 1895.0}$$

$$\begin{aligned} \varphi &= 13\ 47\ 16.33 \\ \mu &= 782''.6076 \\ \log a &= 0.4376414 \end{aligned}$$

$$\Delta\lambda\cos\beta = +0''.04 \quad ; \quad \Delta\beta = -0''.03$$

Lehigh University, 1896 *June*.

SOUTHERN VARIABLE STARS—A REQUEST.

I would deem it a great favor if observers who may have observations of variable stars south of −30° not already made public would communicate them to me, or, preferably, publish them without delay.

I am desirous of securing elements of the better known southern variables that will depend upon both the Cordoba and recent observations. Any observations, therefore, that may be used as stepping stones between the two periods 1871–76, and 1891–96, will be of great value for this purpose.

ALEX. WM. ROBERTS.

Lovedale, South Africa.

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PUBLISHED IN BOSTON TRI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS. P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed August 5.*

THE
ASTRONOMICAL JOURNAL.
No. 382.

VOL. XVI. BOSTON, 1896 AUGUST 20. NO. 22

FLEXURE AND DIVISION-CORRECTION OF THE CIRCLES OF THE MERIDIAN INSTRUMENT AT ALBANY,

BY LEWIS BOSS.

What is known as the "Olcott Meridian Circle" of this observatory, was made by Pistor and Martins in 1856, under the direction of Dr. B. A. Gould. The method which I employed in 1879 for determination of the flexure and division-correction of this instrument differed essentially from any with which I had been previously acquainted. The employment of some method like this for the determination of flexure, was suggested by Professor Newcomb's memoir on the Washington Transit-Circle, in the annual volume of that observatory for 1865; but it was soon perceived that a proper adaptation of the principle would serve for determination of the division-correction also.

Since the instrument has been installed in its present location, as described in no. 334 of this Journal, another and much more elaborate determination of the flexure and division-correction of the circles has been carried out, the results of which may possess some general interest.

The instrument has already been described (*A.J.* no. 334 and elsewhere). It is provided with two circles,—A, at the clamp-end of the axis, and B at the opposite end, each graduated to 2′. The numbers are arranged so that when either circle is east it indicates south zenith-distances, plus a constant. The radius of the graduations, from a point one-third the length of the shorter marks from the ends nearest the center, is 475.7 mm; the linear value of 1″ is therefore 2.3 microns. There are four reading-microscopes on each pier, arranged in the usual manner. They are firmly fastened in holes through the stone pier, and their positions are, in a general sense, invariable. In reading, the eye is at a distance of 595 mm. from the graduations; the actual magnifying power is 84 diameters; from which it is inferred that the effective power is 36 diameters.

In what follows, division-correction will be understood as a quantity applicable to the mean reading of four microscopes; since in this method that is the quantity first determined. The errors of diameters can be readily deduced from the same material of observation, if desired. The zero of reference will be that in which the marks under the four microscopes are 0°, 90°, 180° and 270°.

Let R_m, R_n, etc., indicate successive readings of Circle A, and R'_r, R'_s, etc., the corresponding simultaneous readings of Circle B. With perfect circles, read without error, we shall evidently have,

$$(R_m+R'_r) = (R_n+R'_s) = \ldots\ldots = R_0$$

in which R_0 represents the true, constant sum of the readings. In practice, each of the readings may require corrections, A_m, A_n etc., for Circle A; B_r, B_s etc., for Circle B; so that we shall have,

$$(R_m+R'_r)+A_m+B_r = (R_n+R'_s)+A_n+B_s = \ldots. = R_0 \quad (1)$$

If, now, we have a set of sums of simultaneous readings, t in number, at equidistant intervals, a, on the circles, during a time in which it may be assumed that the true sum, R_0, has remained practically invariable; and if we take the arithmetical mean, R'_0, of the sums $(R_m+R'_r)$, $(R_n+R'_s)$ etc., and subtract it from each individual sum, having reference to equations (1) in the process, we shall have t equations of condition like the following:

$$\left.\begin{array}{l} +\dfrac{(t-1)A_m}{t}-\dfrac{A_n}{t}-\ldots\ldots+\dfrac{(t-1)B_r}{t}-\dfrac{B_s}{t}-\ldots\ldots+(R_m+R'_r)-R'_0 = 0 \\ -\dfrac{A_m}{t}+\dfrac{(t-1)A_n}{t}-\ldots\ldots-\dfrac{B_r}{t}+\dfrac{(t-1)B_s}{t}-\ldots\ldots+(R_n+R'_s)-R'_0 = 0 \end{array}\right\} \quad (2)$$

* * * * * * *

Let similar sets of simultaneous readings (t in number) be continued throughout the quadrant, or circumference, as may be necessary. At the beginning only one set will be required. Then, at the beginning of each successive series, while the axis of the circle remains fixed, let one of the circles be shifted by one of the equidistant spaces, a, so that, for instance, the reading R_m in the new series shall correspond to R'_r, etc.; and in each of the series let sets of simultaneous readings be made as in the first. If, now, in each series, the corrections, as A_m and B_r, are known at regular intervals, ta, and if the number of series be t, we shall be able to solve the equations in a rigorous manner for the values of the remaining unknown corrections. In practice t should not exceed *five*, though the set may be a multiple of t, and the number of series should be much greater than t.

Continuing to neglect for the present other classes of errors, we shall consider those peculiar to the circles themselves. When the graduated circle lies sensibly in the surface of a vertical plane and is of nearly homogeneous construction in the usual form, the principal terms of error due to the construction and action of the circle are of the well known form,

$$A_m + F\sin(R_m + a)$$

In this expression, A_m indicates division-correction. The term, $F\sin(R_m + a)$, is to correct for the effect of flexure of the circle. This flexure is a minute rotation relative to the axis, like that which would result from the application of a load at some point, $a + \beta$, of the divided arc, the circle remaining rigidly clamped to the axis. The actual flexure is, in all probability, the resultant effect of an infinite number of loads unsymmetrically distributed upon the circle, such as might arise from slight variations in the form, or density, of various sections of the circle. A very elementary consideration of the problem is sufficient to show that, under ordinary circumstances, while the flexure remains a small differential, the distortion of form in any well made circle must be practically insignificant. Therefore, the correction $F\sin(R_m + a)$ is equally applicable to the indication of each of the microscopes.

The question whether a given circle follows the simple law, herein stated, is one which may be very easily tested. Among such tests that have been applied to the Albany Circle, two or three may be cited.

Circle A was set to R 350° (Z.D. of telescope, 80°) and the four microscopes were read as in column (1) of the table shortly to be given. Then, the instrument remaining throughout firmly clamped, a weight of 8 ounces (approximately 227 grams) was suspended from the circle at the graduation-mark 35°, which was in the south horizon as viewed from the axis of the instrument; and the readings in column (2) were made. The readings in column (3) were obtained when the weight was suspended from graduation, 215°, 180° distant from its position in series (2): and readings (4), (5) and (6), are respectively duplicates of (2), (3) and (1)—(6) as compared with (1) serving to indicate whether the instrument, as a whole, or the microscopes, had suffered any material changes during the course of the readings.

FLEXURE-TEST

Microscope	(1)	(2)	(3)	(4)	(5)	(6)
	″	″	″	″	″	″
E	34.2	40.7	29.1	40.4	29.3	34.7
F	37.4	43.6	32.3	43.5	32.6	38.1
G	25.5	31.4	19.5	31.0	20.2	25.2
H	32.4	38.1	26.8	37.8	26.9	32.5

From this experiment I conclude that the horizontal flexure of the circle, thus loaded, is 5″.6, or 0″.70 for one ounce. For each microscope, the mean observed effect was: for E, 5″.7; for F, 5″.6; for G, 5″.7; and for H, 5″.6. There appears to be no sensible distortion of the circle produced by the weight. Other similar tests led also to like conclusions. The correction for flexure, as deduced in this experiment, would be 5″.6 $(R+280°)$; for R = 305°, the value of this expression is −4″.0,—exactly that which was observed. Other tests with smaller weights were made, all confirming the same law of the flexure at various points, together with the conclusions already cited; and showing that a weight of one ounce (about 28 grams) fastened to the periphery of the circle is sufficient to cause a flexure of 0″.7. Further testimony as to the applicability of the sine law of flexures to these circles will appear in its proper place.

It is impossible here to enter into consideration of the details relating to the attempt to correct for, or to get rid of, the errors of micrometric measurement upon the circles. No point was knowingly overlooked; and the contest against error was incessant. It is necessary to remark, however, that I have not thoroughly investigated the possible irregularities in the action of the new micrometers of the circle-microscopes. They appear to be small. It was found to be clearly practicable and was deemed to be preferable, in this division-error work, so to conduct the measures as wholly to eliminate, in the final results, the effect of the possible errors in question. The determination of these errors is always difficult, and is liable to its own uncertainty, so that elimination is still desirable, even if the readings are corrected.

Let us now consider the actual series of readings. With the instrument, clamp West, a series of simultaneous readings of the two circles was made with settings at intervals of 45°, throughout the circumference. There were two observers, one at each circle. In the first series, when the telescope pointed to the zenith, the reading of circle A was 270°, and of B 315, and the approximate sum of the readings was 225° 0′ 51″. The first reading in the series was at 180° for A, and 45° for B, the eighth at 225° for A, and 0° for B, the ninth to sixteenth corresponded, in retrograde order, to the first eight readings. The following table exhibits the corrected sums, with the concluded means in the last column, which are uninfluenced by any changes in the instrument, or in the habit of the observers, that are uniformly progressive with the time. Throughout the work, without exception, this arrangement of direct and retrograde sets of readings was kept up.

45° ARCS, CLAMP WEST, SERIES (AND SET) I.

	Degrees of Reading.		Seconds of Sums.		
Order	For A	For B	1st Half	2d Half	Means
	°	°	″	″	″
1–16	180	45	51.56	50.97	51.26
2–15	135	90	51.30	50.71	51.00
3–14	90	135	51.71	51.36	51.54
4–13	45	180	50.82	50.74	50.78
5–12	0	225	50.83	50.41	50.62
6–11	315	270	49.97	49.73	49.85
7–10	270	315	50.99	50.52	50.76
8– 9	225	0	50.40	50.17	50.28

Neglecting degrees in the sums, this series furnishes the following equations: (3)

$$\begin{aligned}
A_0 + B_{45} + F\sin(180^\circ + \alpha) + F'\sin(\ 45^\circ + \alpha') + 51''.26 &= R_0\\
A_{45} + B_0 + F\sin(135 + \alpha) + F'\sin(\ 90 + \alpha') + 51.00 &= R_0\\
A_0 + B_{45} + F\sin(\ 90 + \alpha) + F'\sin(135 + \alpha') + 51.54 &= R_0\\
A_{45} + B_0 + F\sin(\ 45 + \alpha) + F'\sin(180 + \alpha') + 50.78 &= R_0\\
A_0 + B_{45} + F\sin(\ \ 0 + \alpha) + F'\sin(225 + \alpha') + 50.62 &= R_0\\
A_{45} + B_0 + F\sin(315 + \alpha) + F'\sin(270 + \alpha') + 49.85 &= R_0\\
A_0 + B_{45} + F\sin(270 + \alpha) + F'\sin(315 + \alpha') + 50.76 &= R_0\\
A_{45} + B_0 + F\sin(225 + \alpha) + F'\sin(\ \ 0 + \alpha') + 50.28 &= R_0
\end{aligned}$$

By the addition of alternate equations we derive the two equations $51''.04 + B_{45} = R_0$, and $50''.48 + A_{45} = R_0$; and from these,

$$A_{45} - B_{45} - 0''.56 = 0 \tag{4}$$

Circle B was next unclamped, so rotated on the axis that its reading 0° corresponded to 270° for A, and then clamped again. In this new series (II), the readings of A were as in Series I and those of B were all 45° greater. From a set of equations entirely analogous to (3) was derived,

$$A_{45} + B_{45} - 0''.46 = 0 \tag{5}$$

The solution of (4) and (5) gives: $A_{45} = +0''.51$; $B_{45} = -0''.05$. In series (and set) III, 45° of B corresponded to 270° of A; and in each succeeding series the reading of B was increased 45° relatively to A, until eight series were completed. Then B was allowed to remain fixed on the axis while A was rotated in the successive series, eight in number. Similar observations in 16 series, with the instrument, clamp east, in order to secure interchange of observers and microscopes, as well as to strengthen the determination of the principal fundamental point, completed the determination of A_{45} and B_{45}, in 16 individual results as shown in the following list:

DETERMINATION OF A_{45} AND B_{45}

	Clamp W		Clamp E	
	A_{45}	B_{45}	A_{45}	B_{45}
	″	″	″	″
	+0.51	−0.05	+0.56	+0.02
	+0.59	−0.00	+0.70	−0.04
	+0.47	−0.01	+0.50	+0.02
	+0.54	−0.08	+0.54	+0.05
	+0.51	+0.20	+0.61	−0.03
	+0.60	+0.04	+0.62	0.00
	+0.55	+0.11	+0.70	−0.06
	+0.56	−0.03	+0.53	−0.10
Means	+0.54	+0.02	+0.60	−0.02

The definitively adopted values are:

$$A_{45} = +0''.57 \pm 0''.011 \quad ; \quad B_{45} = 0''.00 \pm 0''.015$$

The probable errors of the final results are derived from the 16 independent determinations, but are probably too small.

The method of determining the corrections, A_{30}, A_{60}, B_{30} and B_{60}, were entirely analogous to those employed in determining A_{45} and B_{45}. The interval between settings and relative rotations of the circles was, of course, 30°. The instrument was "clamp east." Each series consisted of a single set of 24 readings, 12 direct and 12 retrograde. There were 12 sets in which B was rotated relatively to A, and 12 sets in which A was rotated relatively to B. Equations were formed analogous to equations (3), and, in order to eliminate flexure, means of corresponding sums in the four quadrants were taken, the first mean having been derived from the 1st, 4th, 7th and 10th sums; the second from the 2d, 5th, 8th and 11th sums; and the third from the 3d, 6th, 9th and 12th sums. Thus, in the first series there resulted:

$$\left.\begin{aligned}
33''.74 &= R_0\\
33.82 + A_{30} + B_{60} &= R_0\\
33.06 + A_{60} + B_{30} &= R_0
\end{aligned}\right. \tag{6}$$

Subtracting one-third the sum of equations (6) from each one of these equations, there result the first three of equations (7). The next three are formed from Series II, and the last three from Series III.

CONDITIONAL EQUATIONS FROM SERIES I, II, III, 30° ARCS.

$$\left.\begin{array}{rrrrrl}
-\frac{1}{3}A_{30} & -\frac{1}{3}A_{60} & -\frac{1}{3}B_{30} & -\frac{1}{3}B_{60} & +0''.20 & = 0\\
+\frac{2}{3} & -\frac{1}{3} & -\frac{1}{3} & +\frac{2}{3} & +0.28 & = 0\\
-\frac{1}{3} & +\frac{2}{3} & +\frac{2}{3} & -\frac{1}{3} & -0.48 & = 0\\
-\frac{1}{3} & -\frac{1}{3} & -\frac{1}{3} & +\frac{2}{3} & +0.26 & = 0\\
+\frac{2}{3} & -\frac{1}{3} & +\frac{2}{3} & -\frac{1}{3} & -0.01 & = 0\\
-\frac{1}{3} & +\frac{2}{3} & -\frac{1}{3} & -\frac{1}{3} & -0.26 & = 0\\
-\frac{1}{3} & -\frac{1}{3} & +\frac{2}{3} & -\frac{1}{3} & +0.21 & = 0\\
+\frac{2}{3} & -\frac{1}{3} & -\frac{1}{3} & -\frac{1}{3} & +0.12 & = 0\\
-\frac{1}{3} & +\frac{2}{3} & -\frac{1}{3} & +\frac{2}{3} & -0.33 & = 0
\end{array}\right\} \quad (7)$$

The entire 24 series of 30° arcs furnished eight sets of equations like equations (7), or 72 conditional equations in all. The solution of equations (7) leads to the normal equations,

$$\begin{array}{rrrrr} 2A_{30} & -\ A_{60} & & & +0''.39 = 0 \\ -\ A_{30} & +2A_{60} & & & -1.07 = 0 \\ & & +2B_{30} & -\ B_{60} & -0.28 = 0 \\ & & -\ B_{30} & +2B_{60} & +0.21 = 0 \end{array}$$

From these result: $A_{30} = +0''.10$; $A_{60} = +0''.58$; $B_{30} = +0''.12$; $B_{60} = -0''.05$. In the formation of the normal equations throughout this and all other parts of the work some abridgements were possible that greatly facilitated the solutions. Thus, for the sums of squares of the coefficients, we have for each group of three, $\frac{2}{3}$; and for the sums of products, $+\frac{2}{3}$ when the positive coefficients are found in the same horizontal line, $-\frac{1}{3}$ when they are found in different lines. For the absolute terms of the normal equations it is simply necessary to sum the absolute terms of the individual equations in which positive coefficients of a given unknown occur. One of the chief advantages of this method lies in the simplicity of the numerical solutions, concomitant with entire rigor and refinement. The eight deduced values for A_{30}, A_{60}, B_{30} and B_{60} are exhibited in the following statement:

Series	A_{30}	A_{60}	B_{30}	B_{60}
	″	″	″	″
I–III	+0.10	+0.58	+0.12	−0.05
IV–VI	+0.01	+0.45	+0.13	−0.10
VII–IX	+0.02	+0.52	+0.06	−0.15
X–XII	+0.05	+0.36	−0.02	−0.22
XIII–XV	+0.01	+0.35	+0.14	−0.06
XVI–XVIII	−0.04	+0.31	+0.07	−0.04
XIX–XXI	+0.10	+0.47	+0.15	−0.10
XXII–XXIV	+0.05	+0.44	+0.16	−0.02
Means	+0.04	+0.44	+0.10	−0.09

The mean of the probable errors for the final means is ±0″.015, if computed from the individual determinations, and ±0″.012 if computed from the equations.

We can now proceed with the determination of the flexures of the circles. For example, in equations (3), A_{45} and B_{45} being known, R_0 can be found (=51″.04); and we shall have a series of conditional equations in which the flexures are the only unknown quantities. The four divisions of the 45° arcs, and the two divisions of the 30° arcs, each furnish a set of equations, with complete elimination of errors, for the determination of flexure of each of the circles. The final results are exhibited in the following statement, in which the first column shows the division, the second designates which circle remained fixed, the third, the constant zenith-reading of that circle; and the remaining columns contain the coefficients of the sine and cosine terms as indicated. In these and all other final results for flexure, or division-corrections, the third decimal of seconds was carried out in the computations.

Determination of Flexure.

		Circle A		Circle B	
Div.	z, R	sin R	cos R	sin R	cos R
		″	″	″	″
45° W	A 270	−0.70	−0.39	−0.44	−0.63
	B 270	−0.64	−0.38	−0.56	−0.71
45° E	B 0	−0.61	−0.32	−0.49	−0.70
	A 270	−0.68	−0.26	−0.37	−0.66
30° E	A 270	−0.65	−0.32	−0.45	−0.71
	B 270	−0.57	−0.19	−0.45	−0.60
	Means	−0.64	−0.31	−0.46	−0.67

Written in another form we have for the flexure of Circle A, 0″.71 sin(R+205° 46′); and for Circle B, +0″.81 sin(R+235° 18′). I infer, therefore, that the flexure of Circle A could be reduced approximately to zero by fastening a weight of one ounce (approximately 28 grams) to the rim of the circle at the graduation-mark 109° 14′; and that the same could be accomplished for Circle B, by fastening a weight of 1.2 ounces at the mark 79° 42′.

It is worth while to inquire whether the flexures show any marked dependence upon the position in which the circles are clamped upon the axis. The preceding statement of detailed results for flexure affords the means for doing this. We have

A 270°	−0″.68 sin R	−0″.32 cos R	3 determ.
A rotated	−0.61 sin R	−0.30 cos R	3 determ.
B 0	−0.49 sin R	−0.70 cos R	1 determ.
B 270	−0.51 sin R	−0.65 cos R	2 determ.
B rotated	−0.42 sin R	−0.67 cos R	3 determ.

The discrepancies between the determinations classified in this manner are no greater than might be attributed to the accidental errors of observation. It has been very evident to me, from the first, that these quantities are due to the flexures of the spokes, or radial arms. These spokes are ten in number for each circle. They are set on a central hub, or disc, 182 mm. in diameter and are 380 mm. in length. The cross-sections of these spokes are trapezoids, the bases of which are in the plane of the graduations. At junction with the hub, the two parallel sides of the cross-section are 15 mm. and 6 mm., and the height is 33 mm.; correspondingly at junction with the arc these dimensions are respectively 10, 6 and 19 mm. I should suppose a **T**-section for these spokes preferable.

In order to gain a general view of the results of the investigation for flexure, and to examine in what degree the sine-law of flexure applies, the following table has been prepared. After substitution of division-correction and R_0 in equations (3), it is easy to arrange the equations of a given division (8 series in the 45° arcs, and 12 series in the 30° arcs) so that the means of a given division (of 8 or 12) shall give directly the flexure of a given reading for one of the circles, apart from every hypothesis as to the law of flexure, except that for the opposite circle it has opposite signs for readings 180° apart, a hypothesis which has received the strongest confirmation. The separate determinations n_1, n_2, etc., furnish the means in column "O." Column C contains the values calculated from the definitive formulas.

DETAILS OF OBSERVED FLEXURES.

CIRCLE A

R	n_1	n_2	n_3	n_4	n_5	n_6	O	C
°	″	″	″	″	″	″	″	″
0	−0.31	−0.32	−0.32	−0.33	−0.38	−0.27	−0.32	−0.31
30	. .	. .	. .	. .	−0.58	−0.42	−0.50	−0.59
45	−0.72	−0.74	−0.94	−0.84	. .	. .	−0.81	−0.67
60	. .	. .	. .	. .	−0.75	−0.54	−0.64	−0.71
90	−0.54	−0.58	−0.65	−0.66	−0.69	−0.61	−0.62	−0.64
120	. .	. .	. .	. .	−0.34	−0.44	−0.39	−0.40
135	−0.33	−0.11	−0.16	−0.07	. .	. .	−0.17	−0.23
150	. .	. .	. .	. .	−0.03	−0.13	−0.08	−0.05
180	+0.18	+0.28	+0.37	+0.38	+0.34	+0.28	+0.30	+0.31
210	. .	. .	. .	. .	+0.52	+0.47	+0.50	+0.59
225	+0.69	+0.60	+0.78	+0.65	. .	. .	+0.68	+0.67
240	. .	. .	. .	. .	+0.74	+0.44	+0.59	+0.71
270	+0.72	+0.60	+0.61	+0.58	+0.66	+0.66	+0.64	+0.64
300	. .	. .	. .	. .	+0.37	+0.44	+0.40	+0.40
315	+0.31	+0.27	+0.31	+0.30	. .	. .	+0.30	+0.23
330	. .	. .	. .	. .	+0.14	+0.12	+0.13	+0.05

CIRCLE B

R	n_1	n_2	n_3	n_4	n_5	n_6	O	C
°	″	″	″	″	″	″	″	″
0	−0.70	−0.71	−0.58	−0.68	−0.69	−0.64	−0.67	−0.67
30	. .	. .	. .	. .	−0.93	−0.75	−0.84	−0.81
45	−0.52	−0.86	−0.84	−0.93	. .	. .	−0.79	−0.80
60	. .	. .	. .	. .	−0.75	−0.64	−0.70	−0.73
90	−0.47	−0.45	−0.36	−0.52	−0.40	−0.52	−0.45	−0.46
120	. .	. .	. .	. .	+0.03	−0.07	−0.02	−0.07
135	+0.10	+0.16	+0.10	+0.09	. .	. .	+0.11	+0.14
150	. .	. .	. .	. .	+0.32	+0.30	+0.31	+0.35
180	+0.74	+0.65	+0.61	+0.64	+0.72	+0.67	+0.67	+0.67
210	. .	. .	. .	. .	+0.80	+0.68	+0.74	+0.81
225	+0.78	+0.82	+0.77	+1.03	. .	. .	+0.85	+0.80
240	. .	. .	. .	. .	+0.74	+0.68	+0.71	+0.73
270	+0.37	+0.56	+0.44	+0.45	+0.49	+0.40	+0.45	+0.46
300	. .	. .	. .	. .	+0.07	+0.16	+0.12	+0.07
315	−0.29	−0.18	−0.15	−0.07	. .	. .	−0.17	−0.14
330	. .	. .	. .	. .	−0.39	−0.28	−0.34	−0.35

The further work of ascertaining division-error might have been carried on in a single quadrant, except that it is desirable to eliminate certain classes of errors to which allusion has been made. Accordingly in all the divisions of the work, except in that of the 1° and the 20′ arcs, readings were made in opposite quadrants in each series, or relation of the circles, and often in all four quadrants.

The errors of A_{15}, A_{75}, B_{15} and B_{75} were ascertained by special methods, differing somewhat from that which has been described. There were 32 determinations which are here condensed into four distinct sets, or methods.

DETERMINATION OF A_{15}, A_{75}, B_{15}, B_{75}.

Division	A_{15}	A_{75}	B_{15}	B_{75}
	″	″		
I	+0.24	+0.44	−0.05	−0.04
II	+0.27	+0.41	−0.11	−0.12
III	+0.38	+0.45	+0.01	−0.04
IV	+0.36	+0.50	0.00	−0.02
Means	+0.31	+0.45	−0.04	−0.06

From combination of pairs of determinations (all possible) in these final results, the probable error of the adopted means is ±0″.019, which is probably not materially smaller than the true probable error. We have now the value of the correction for flexure and division error for every multiple of 15° in the entire circumference.

As a separate foundation upon which to base the subsequent work, the multiples of 9° were investigated next. There were 40 series of readings in this division of the work. Each series consisted of four sets, and there were 10 readings in each set, five direct and five retrograde. The readings gave rise to 800 equations of condition, illustrated by the following set of five.

A_{54}	A_{63}	A_{72}	A_{81}	B_9	B_{18}	B_{27}	B_{36}	n
								″
−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	+0.17 = 0
−0.2	−0.2	−0.2	+0.8	+0.8	−0.2	−0.2	−0.2	−0.58 = 0
−0.2	−0.2	+0.8	−0.2	−0.2	+0.8	−0.2	−0.2	+0.44 = 0
−0.2	+0.8	−0.2	−0.2	−0.2	−0.2	+0.8	−0.2	−0.17 = 0
+0.8	−0.2	−0.2	−0.2	−0.2	−0.2	−0.2	+0.8	+0.14 = 0

Four sets of normal equations were formed and solved; and from a final set of normal equations, containing the results of the entire division, were taken the definitive values of the unknown corrections; which for each circle were not only independent from the adopted value of the flexure, but also from the division corrections of the other circle. The final determinations in two sets, formed under the condition that in each there shall be nominally complete elimination of the unknown residual errors of flexure, of irregularities of the micrometer screws, etc., are these:

DIVISION CORRECTION FOR 9° ARCS.

	CIRCLE A			CIRCLE B		
R	(1)	(2)	Mean	(1)	(2)	Mean
°	″	″	″	″	″	″
9	−0.15	−0.21	−0.18	+0.17	+0.19	+0.18
18	−0.22	−0.22	−0.22	−0.08	−0.10	−0.09
27	−0.04	−0.11	−0.07	+0.23	+0.27	+0.25
36	+0.50	+0.47	+0.48	−0.35	−0.30	−0.33
54	+0.45	+0.46	+0.46	−0.10	−0.14	−0.12
63	+0.14	+0.16	+0.15	−0.46	−0.47	−0.46
72	−0.14	−0.11	−0.12	−0.26	−0.24	−0.25
81	+0.60	+0.65	+0.62	+0.12	+0.15	+0.14

From the agreement of these 16 pairs of determinations, the probable error of an adopted mean would appear to be ±0″.012. From the 100 final conditional equations it is ±0″.016; even this is probably too small. I have therefore taken the probable error from the solutions in four sets, although the errors are not completely eliminated. The probable error of the final means from this source is ±0″.029. This is probably too large, but is adopted. There were several rather anomalous results in this series. B_{72} affords the most marked instance. The separate values for this point were −0″.09, −0″.43, −0″.11 and −0″.37. A special determination of B_{72}, symmetrically arranged under the assumption that the corrections of all other multiples of 9° are known, gave −0″.22 ± 0″.03, while the previously adopted value was −0″.25. It is probable that there was here an exceptionally unlucky combination of uneliminated systematic and accidental errors.

The corrections for arcs which are multiples of 3° were next determined. There were two independent divisions of this work. In the first there were six series; in each series 24 sets, extending around the entire circumference; and in each set there were 12 readings, each set beginning and turning at the middle on a multiple of 15°, for circle A. In the second division there were six readings in each set, 20 sets in each series, in opposite quadrants, and 9 series. Each set for Circle A began on a multiple of 9°. The first division furnished two determinations which proved to have, each, exactly the weight of the determination from the second division.

RECAPITULATION OF 3° ARCS.

	CIRCLE A				CIRCLE B			
R	1	2	3	Mean	1	2	3	Mean
	″	″	″	″	″	″	″	″
3	—0.31	—0.33	—0.24	—0.29	—0.46	—0.36	—0.45	—0.42
6	—0.13	—0.13	—0.06	—0.11	+0.04	+0.02	+0.09	+0.05
12	—0.04	—0.15	—0.08	—0.09	+0.02	+0.16	+0.11	+0.10
21	—0.01	—0.06	—0.11	—0.06	+0.26	+0.13	+0.17	+0.19
24	—0.14	—0.05	—0.02	—0.07	+0.19	+0.09	+0.03	+0.11
33	—0.04	+0.07	+0.02	+0.02	—0.10	—0.01	+0.08	—0.01
39	+0.16	+0.25	+0.25	+0.22	—0.17	—0.12	—0.17	—0.16
42	+0.45	+0.46	+0.59	+0.50	—0.03	+0.10	—0.06	0.00
48	+0.54	+0.46	+0.58	+0.53	—0.07	+0.02	—0.05	—0.03
51	+0.41	+0.35	+0.49	+0.42	—0.08	—0.04	—0.04	—0.05
57	+0.51	+0.48	+0.48	+0.49	—0.31	—0.40	—0.32	—0.35
66	+0.16	+0.25	+0.10	+0.17	—0.23	—0.21	—0.11	—0.18
69	+0.01	+0.20	+0.05	+0.09	—0.01	—0.15	—0.07	—0.08
78	+0.28	+0.31	+0.26	+0.28	—0.21	—0.35	—0.18	—0.25
84	+0.61	+0.57	+0.41	+0.53	+0.13	+0.25	+0.28	+0.22
87	+0.33	+0.45	+0.46	+0.41	—0.13	—0.14	—0.14	—0.13

The probable error of the adopted means is ±0″.026; and this is probably very near the truth. In the determination of these 3° arcs the symmetry was somewhat disturbed, and all of the equations had to be written out. This was because the determination rested on two series of basic points,—the 9° and the 15° arcs. One great advantage anticipated from this arrangement is that systematic errors in the determination of the 3° arcs are probably much smaller than they would have been had they depended upon either the 15° or 9° arcs alone.

The further subdivision of the circles presents no point of special interest, not brought out in what precedes. The multiples of 3° were next divided into single degrees. There were read 18 series, each containing 30 sets of 8 readings, all in one quadrant. Each set began and turned upon a multiple of 3° on Circle A, Circle B having been rotated 1° at the beginning of each series. The equations were solved in two sets of normal equations, and also in a final set comprehending all the material. The solutions were practically rigorous in this as in all preceding instances. Although there were 120 normal equations containing 120 unknown quantities, the final solution by successive approximation (from predicted first values) correct to the third decimal place, occupied less than a week for the three sets of normal equations. From the 120 pairs of values, the probable error of the adopted means for 1° arcs is ±0″.032 (by squares). The average difference between the two halves was 0″.075; the largest difference was 0″.26; and only 13 of the 120 differences amounted to 0″.15, or more.

The determination for multiples of 20′ required the solution of three sets of 360 normal equations containing 360 unknown quantities, one for each half of the observations and one for the final summary. These equations were derived from 12 series, of 90 sets each, precisely like those for the 1° arcs, except that the interval was only 20′ instead of 1°. There were 4320 equations of condition. Comparing the solution from the two halves, the mean difference of the results for Circle A was 0″.094, and for Circle B, 0″.066. The probable error (from squares) of the adopted determinations for Circle A was ±0″.040, and for Circle B it was ±0″.030. The difference of precision might be accounted for by supposing that the observers on Circle A measured with the same precision (systematically) as in their measures for the 1° arcs, while those for Circle B decidedly improved. In the determination of the 20′ arcs, the largest difference between any pair of results for the same point, from the two halves, was 0″.28; there were 15 differences for Circle A, and 3 for Circle B, that were greater than 0″.2; and in 307 instances out of 360 (139 for Circle A, and 168 for Circle B) the differences were less than 0″.15.

I am satisfied that the determinations, both for the 1° and the 20′ arcs, would have been decidedly more precise, and less liable to systematic error had each set consisted of 14 readings instead of 8, with a saving of one in eight, as to the number of readings.

(Continued in No. 383.)

ON THE VARIABILITY OF (6549) —*LYRAE* (ANDERSON).

BY PAUL S. YENDELL.

The probable variability of this star was announced by ANDERSON, in No. 3329 of the *Astronomische Nachrichten*.

Since May 7 of the current year, I have six observations of the star, which appear to place its variability beyond question.

They are as follows:

1896 May	7	glimpsed	12^{M}
	12	not seen:	limit, $<11^{M}$
	27	“ “	“ $<10^{M}$
July	12	glimpsed	12^{M}
Aug.	4	$9^{M}.5$	
	8	$9^{M}.4$	

Dorchester, Mass., 1896 *August* 9.

DOUBLE-STAR OBSERVATIONS,

MADE WITH THE 16-INCH REFRACTOR AND FILAR MICROMETER OF GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY F. P. LEAVENWORTH.

[Communicated by the Director, W. W. PAYNE.]

The following observations of double stars were made by Professor F. P. LEAVENWORTH of the State University of Minnesota (formerly Director of Haverford College Observatory), while spending a part of the summer vacation of 1893 at Northfield. The observations were made in the same manner as those by the same observer at Haverford and at the Leander McCormick Observatory, which have been published. Generally four measures of position-angle and two measures of double distance were taken on each night. The eyes were placed either parallel or normal to the line joining the stars. The magnitudes of the stars were estimated independently on each night.

The defining power of the 16-inch telescope is most excellent, so that on a fairly good night, stars of 0″.5 distance are easy objects, and on the best nights the diffraction discs of stars of 0″.3 distance are clearly separated. A magnifying power of 600 was used in all the measures.

Most of the stars are from a list, furnished by Mr. S. W. BURNHAM, of his own stars, which had been measured but once or not at all before, or had been found to give evidence of motion. A few of the Struve stars were observed to fill up the time. The aim was to observe each star on three nights, but as Mr. H. C. WILSON was working on the same list, in many cases the two observers measured the same star, each on two different nights. Mr. WILSON's results will be published later.

Star's name	R.A. 1900	Decl. 1900	Year	Position angle	Distance	No. obs.	Magnitudes	
	h m	° ′		°	″		M	M
Σ1820	14 10	+55 48	1893.519	72.4	2.19	2	8.0	8.3
β 238	14 28	−20 36	.475	90.6	6.94	1	. .	. .
Σ1865	14 36	+14 9	.528	277.5	0.34	2	4.0	4.1
ΟΣ 285	14 42	+42 48	.518	332.3	0.29	2	Equal	
Σ1932	15 14	+27 12	.541	320.2	0.81	2	6.0	6.1
Σ1937	15 19	+30 39	.502	242.8	0.50	3	6.0	6.1
Σ1998 AB	15 59	−11 6	.510	210.9	0.88	2	5.0	5.2
AB–C	. .	. .	.510	67.2	7.43	2	. .	7.0
Σ2032	16 11	+34 7	.489	210.4	4.09	1	6.0	7.5
Σ2055	16 26	+ 2 12	.534	48.8	1.43	2	4.0	5.2
Δ 15	16 41	+43 10	.542	347.6	0.44	2	8.0	8.4
β1117	16 51	−22 59	.504	270.6	0.56	2	6.1	6.4
Σ3107	16 54	+ 4 6	.522	97.0	1.32	2	8.0	8.3
Σ2130	17 3	+54 36	.534	335.2	2.32	2	5.0	5.1
H.C.W. AB	17 13	+26 41	.489	40.8	0.60	1	8.0	9.5
Σ2173	17 25	− 0 59	.546	157.4	1.14	1	. .	. .
β 826	18 3	+ 9 45	.520	333.2	0.59	2	9.8	9.9
β 638 AB	18 5	+ 2 34	.513	152.1	21.86	3	8.4	9.2
BC	. .	. .	.505	5.5	1.48	4	. .	12.2
β 285 AB	18 11	−25 2	.549	319.1	1.57	1	7.5	9.8
β 135	18 32	−14 6	.539	187.6	2.24	2	7.0	12.5
β 967	18 35	−14 36	.541	191.1	2.33	3	7.8	11.8
β 971	18 45	+49 19	.518	107.0	0.25 est.	2	. .	. .
β 421 AB	18 49	+43 16	.494	288.5	0.90	2	9.0	9.2
β 972 AB	18 51	− 0 42	.496	5.4	0.94	2	8.6	9.4
AB–C	. .	. .	.496	14.2	73.48	2	. .	9.0
β 648	18 53	+32 47	.490	240.2	1.40	2	6.0	8.8
β 142	19 23	−12 21	.489	330.8	1.53	3	7.4	7.9
β 143	19 27	+49 18	.512	192.9	2.15	3	7.8	8.7
β 147	19 42	+31 52	.541	297.6	8.86	3	8.3	9.3
β 979	19 48	+23 1	.536	335.9	2.25	4	8.1	11.5
β 149 AB	19 54	+16 13	.546	278.6	126.57	3	6.5	9.9
BC	. .	. .	.544	199.8	8.32	4	. .	12.5
β 426	20 1	+54 22	.496	310.1	5.71	3	8.1	10.7
β 427	20 1	+54 24	.496	335.7	2.93	3	8.3	10.4
β 150 BC	20 7	+33 20	.515	187.7	1.85	3	8.0	9.8
β 430 AB	20 8	+35 32	.516	21.1	0.98	3	8.9	10.0
AC	. .	. .	.549	52.5	17.15	1	. .	9.3
β 982	20 8	+26 4	.515	50.1	0.81	3	9.1	10.3
β 441	20 13	+28 50	.515	65.6	5.93	3	6.3	11.5
β 670	20 28	+13 36	1893.515	47.3	0.53	3	8.5	8.9

Star's name	R.A. 1900 h m	Decl. 1900	Year	Position angle	Distance ″	No. obs.	Magnitudes M	M
β 151 AB	20 33	+11 15	1893.520	339.2	0.58	2	4.0	7.0
β 366 AB	20 45	+50 7	.550	127.5	1.24	2	8.2	8.5
CD	. .	.	.549	1.2	1.35	1	10.0	11.0
β 173	21 2	−10 37	.536	114.9	1.88	2	8.5	10.0
β 71	21 31	+20 57	.533	319.9	1.32	3	7.3	8.9
β 374	21 40	+50 33	.541	141.3	1.86	3	8.3	10.5
β 989	21 40	+25 41	.513	121.0	0.29	3	4.0	4.1
β 176	22 10	+30 51	.543	92.5	2.57	4	9.4	10.0
β 991	22 10	+52 1	.548	143.4	0.57	2	8.0	8.2
β 177	22 11	+30 55	.543	43.5	6.48	4	9.0	9.8
β 277	22 35	+40 51	.546	201.9	0.49	1	8.0	8.4
β 450 AC	22 40	+38 57	.535	231.8	10.86	1	7.0	12.5
β 382	22 49	+44 13	.528	221.3	0.91	3	6.2	8.0
β 79	23 12	− 2 4	.546	87.7	0.86	1	8.0	9.0
β 80	23 14	+ 4 52	.546	328.0	0.81	1	8.4	9.0
β 1266 AB	23 25	+30 47	.546	65.9	0.23	1	Equal	
β 720	23 29	+30 47	.546	331.3	0.30	1	6.0	6.5
β 733	23 57	+26 34	1893.546	Not separated		1		

ON THE VARIATION OF THE PERSONAL EQUATION WITH THE MAGNITUDE OF THE STARS OBSERVED.

By JOHN T. HEDRICK, S.J., Assistant.

The following table may be of interest in connection with some estimates that have been published lately of the effect of the personal equation on the right-ascensions of stars of different magnitudes. The quantities contained in it are the corrections to the various catalogues mentioned, which were given by a series of photographic observations of transits, carried out at this Observatory by the Rev. Geo. A. Fargis, S.J., according to a method devised by him. It is copied from an account of the series about to be published. No corrections have been applied to these quantities on account of systematic differences depending on the right-ascension or declination, but except for first-magnitude stars, such corrections could make no essential change in them on account of the general uniformity of distribution of the stars.

The catalogues are: the Berlin *Jahrbuch*, the Greenwich Observations for 1889, the Greenwich Catalogue of Clock-Stars from 12-hour groups (from the introduction of the 10-year Catalogue), and the Madison Meridian-Circle Catalogue from observations in 1887–1892. The second column for each catalogue contains the number of common stars.

The Madison observations seem the best adapted to show the effect of personal equation, as they rest on the same fundamental right-ascensions as the photographic observations, namely, those of the *Jahrbuch*, and are the work of only three observers, and in great part of a single observer. The number of common stars is also greater for it. If the first-magnitude stars are neglected, the remaining mean corrections for Madison may be explained by a change in the personal equation of about 0ˢ.015 for each whole magnitude, the brighter stars being observed visually too early relatively to the fainter ones.

Mag.	*Jahrbuch* s		Gr. 1889 s		Gr. Clock s		Madison s	
1	+0.007	13	−0.017	11	+0.034	11	+0.017	11
2.0	+0.008	25	−0.011	9	+0.019	12	+0.011	20
2.3	+0.006	19	+0.017	9	+0.018	10	+0.014	13
2.6	−0.015	14	+0.010	7	+0.013	7	+0.007	11
3.0	−0.012	31	−0.025	15	+0.010	11	−0.004	29
3.4	−0.005	37	+0.016	11	+0.034	10	−0.005	32

Georgetown College Observatory, 1896 *Aug.* 10.

NOTICE.

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Notice.

Published in Boston, tri-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed August* 18.

THE
ASTRONOMICAL JOURNAL.
No. 383.

VOL. XVI. BOSTON, 1896 SEPTEMBER 4. NO. 23

FLEXURE AND DIVISION-CORRECTION OF THE CIRCLES OF THE MERIDIAN INSTRUMENT AT ALBANY,

By LEWIS BOSS.

(Continued from No. 382.)

The following table contains the definitive values of all the division-corrections which have thus far been determined in this investigation.

Table of Adopted Division-Correction.

R	A	B
° ′	″	″
0 0	0.00	0.00
20	−0.01	+0.02
40	+0.29	−0.27
1 0	−0.09	−0.09
20	−0.19	−0.16
40	−0.35	−0.36
2 0	+0.05	−0.36
20	−0.25	−0.13
40	−0.44	−0.51
3 0	−0.29	−0.42
20	−0.52	−0.34
40	−0.42	−0.49
4 0	−0.24	−0.46
20	−0.11	−0.26
40	−0.06	−0.44
5 0	−0.11	−0.02
20	−0.17	−0.20
40	+0.02	−0.22
6 0	−0.11	+0.05
20	−0.11	−0.05
40	−0.16	−0.30
7 0	−0.13	−0.01
20	−0.02	+0.17
40	−0.06	−0.06
8 0	−0.25	−0.13
20	−0.31	−0.01
40	−0.40	−0.37
9 0	−0.18	+0.18
20	−0.11	+0.24
40	−0.16	+0.13
10 0	−0.32	+0.14
20	−0.25	+0.18
40	−0.34	−0.01
11 0	−0.15	+0.05
20	−0.21	+0.15
11 40	−0.16	−0.13
12 0	−0.09	+0.10
20	−0.14	−0.02
40	−0.32	−0.18
13 0	−0.29	+0.04
20	−0.28	+0.19
40	−0.50	−0.12
14 0	−0.12	+0.11
20	−0.32	+0.10
40	−0.59	−0.18
15 0	+0.31	−0.04
20	+0.28	−0.07
40	+0.12	−0.12
16 0	+0.03	−0.07
20	+0.26	+0.09
40	−0.11	−0.25
17 0	+0.02	−0.03
20	+0.25	+0.06
40	+0.16	−0.08
18 0	−0.22	−0.09
20	−0.38	−0.02
40	−0.52	−0.18
19 0	−0.10	0.00
20	−0.25	+0.10
40	−0.31	0.00
20 0	+0.05	+0.07
20	+0.21	+0.24
40	+0.10	−0.02
21 0	−0.06	+0.19
20	−0.18	+0.07
40	−0.18	−0.15
22 0	−0.06	−0.06
20	+0.05	+0.40
40	−0.10	+0.01
23 0	−0.01	−0.06
20	−0.09	+0.09
23 40	−0.20	−0.10
24 0	−0.07	+0.11
20	−0.26	+0.07
40	−0.15	+0.05
25 0	+0.33	+0.13
20	+0.62	+0.09
40	+0.35	−0.12
26 0	+0.42	+0.08
20	+0.40	+0.15
40	+0.21	−0.14
27 0	−0.07	+0.25
20	+0.30	+0.12
40	+0.21	+0.03
28 0	+0.33	+0.10
20	+0.40	−0.04
40	+0.45	+0.08
29 0	+0.19	+0.30
20	+0.24	+0.29
40	+0.31	−0.11
30 0	+0.04	+0.10
20	+0.05	−0.08
40	−0.24	−0.02
31 0	−0.23	+0.01
20	−0.02	+0.10
40	−0.16	−0.19
32 0	+0.06	+0.03
20	+0.16	+0.01
40	+0.20	−0.13
33 0	+0.02	−0.01
20	+0.14	+0.27
40	−0.11	−0.04
34 0	−0.01	−0.06
20	+0.25	−0.11
40	+0.21	−0.26
35 0	+0.37	0.00
20	+0.20	−0.01
40	−0.02	−0.10
36 0	+0.48	−0.33
20	+0.35	−0.11
40	+0.05	−0.33
37 0	+0.45	−0.12
20	+0.31	−0.11
37 40	+0.17	−0.38
38 0	+0.56	−0.12
20	+0.43	−0.25
40	+0.18	−0.41
39 0	+0.22	−0.16
20	+0.29	+0.07
40	+0.06	−0.23
40 0	+0.31	+0.11
20	+0.50	+0.18
40	+0.27	−0.19
41 0	+0.58	0.00
20	+0.33	−0.21
40	+0.35	−0.19
42 0	+0.50	0.00
20	+0.59	0.00
40	+0.44	−0.05
43 0	+0.46	−0.17
20	+0.43	−0.35
40	+0.25	−0.53
44 0	+0.49	−0.17
20	+0.68	+0.02
40	+0.32	−0.25
45 0	+0.57	0.00
20	+0.62	−0.28
40	+0.53	−0.45
46 0	+0.54	−0.15
20	+0.66	−0.02
40	+0.31	−0.43
47 0	+0.44	−0.27
20	+0.45	−0.19
40	+0.45	−0.32
48 0	+0.53	−0.03
20	+0.46	−0.24
40	+0.23	−0.33
49 0	+0.41	−0.09
20	+0.54	−0.03
40	+0.55	−0.18
50 0	+0.14	+0.07
20	+0.55	+0.26
40	+0.58	+0.03
51 0	+0.42	−0.05
20	+0.54	−0.11
51 40	+0.75	−0.30

R		A	B
°	′	″	″
52	0	+0.38	−0.47
	20	+0.57	+0.02
	40	+0.58	−0.08
53	0	+0.48	−0.30
	20	+0.64	−0.30
	40	+0.40	−0.08
54	0	+0.46	−0.12
	20	+0.77	−0.28
	40	+0.54	−0.21
55	0	+0.50	−0.28
	20	+0.53	−0.25
	40	+0.17	−0.21
56	0	+0.40	−0.29
	20	+0.55	−0.03
	40	+0.31	−0.40
57	0	+0.49	−0.35
	20	+0.75	−0.17
	40	+0.73	−0.48
58	0	+0.49	−0.31
	20	+0.57	−0.17
	40	+0.68	−0.58
59	0	+0.62	−0.21
	20	+0.43	−0.08
	40	+0.24	−0.38
60	0	+0.44	−0.09
	20	+1.03	−0.18
	40	+0.73	−0.28
61	0	+0.17	−0.34
	20	+0.36	−0.34
	40	+0.12	−0.38
62	0	+0.27	−0.23
	20	+0.22	−0.25
	40	+0.39	−0.37
63	0	+0.15	−0.46
	20	+0.08	−0.27
	40	+0.07	−0.51
64	0	+0.23	−0.41
	20	−0.04	−0.24
	40	−0.15	−0.49
65	0	+0.37	−0.11
	20	+0.19	−0.12
	40	+0.20	−0.41
66	0	+0.17	−0.18
	20	+0.10	−0.07
	40	−0.04	−0.30
67	0	+0.24	−0.35
	20	+0.28	−0.36
	40	+0.20	−0.46
68	0	+0.15	−0.34
	20	+0.33	−0.16
	40	+0.26	−0.42
69	0	+0.09	−0.08
	20	+0.22	−0.07
	40	+0.18	−0.12
70	0	+0.02	−0.13
	20	−0.09	−0.04
	40	−0.11	−0.27
71	0	−0.18	−0.21
	20	+0.11	−0.21
	40	−0.13	−0.38
72	0	−0.12	−0.25
	20	−0.11	−0.37
	40	−0.54	−0.42
73	0	−0.09	−0.36
	20	−0.23	−0.39
	40	−0.59	−0.46
74	0	−0.02	−0.35
	20	+0.02	−0.39
	40	−0.29	−0.50
75	0	+0.15	−0.06
	20	+0.63	−0.02
	40	+0.35	−0.30
76	0	+0.42	−0.24
	20	+0.28	−0.34
	40	−0.40	−0.54
77	0	+0.49	−0.24
	20	+0.48	−0.23
	40	+0.44	−0.34
78	0	+0.28	−0.25
	20	+0.41	−0.10
	40	+0.18	−0.50
79	0	+0.18	−0.17
	20	+0.31	+0.23
	40	−0.07	−0.15
80	0	+0.19	−0.02
	20	+0.44	−0.16
	40	+0.27	−0.32
81	0	+0.62	+0.14
	20	+0.32	+0.07
	40	+0.41	−0.08
82	0	+0.66	−0.11
	20	+0.37	−0.11
	40	+0.19	−0.20
83	0	+0.50	+0.02
	20	+0.31	+0.19
	40	+0.33	0.00
84	0	+0.53	+0.22
	20	+0.70	+0.03
	40	+0.34	−0.18
85	0	+0.34	−0.14
	20	+0.37	−0.01
	40	−0.03	−0.13
86	0	+0.11	−0.06
	20	+0.32	−0.16
	40	+0.11	−0.50
87	0	+0.41	−0.13
	20	+0.56	−0.01
	40	+0.17	−0.19
88	0	+0.36	−0.09
	20	+0.07	−0.15
	40	−0.06	−0.37
89	0	+0.09	−0.29
	20	+0.19	+0.15
	40	−0.06	−0.13
90	0	0.00	0.00

Some testimony as to the systematic and casual errors of this investigation can be derived from a comparison with the results obtained for the same circles in 1880. The circle-microscopes, now in use, are as different as well could be from those of 1880. The objectives and micrometer-screws are different; the microscopes are much shorter than before; and the magnifying power now is 36, while it was only 22 then. The former investigation, though pains-taking, was much inferior in accuracy to that of the present. In 1880 the division-correction was determined for every 5° of each circle; after that to every 2° 30′, and then to every 50′ of Circle A, and to the same limit for a restricted arc of B. Therefore the full comparison must be limited to the 5° points. All of these points which are not multiples of 15° are in the fourth step of the present investigation, and in the third of that for 1880; yet, I consider the weight of the old values to be certainly not greater than one-half that of the recent results. The zero of reference in the former investigations has been arbitrarily altered by the addition of a constant.

COMPARISON OF DIVISION CORRECTIONS AS DETERMINED IN 1880 AND 1895.

	CIRCLE A			CIRCLE B		
R	1880	1895	Diff.	1880	1895	Diff.
°	″	″	″	″	″	″
0	−0.15	0.00	+0.15	−0.04	0.00	+0.04
5	0.00	−0.11	−0.11	+0.08	−0.02	−0.10
10	−0.30	−0.32	−0.02	+0.05	+0.14	+0.09
15	+0.20	+0.30	+0.11	−0.02	−0.04	−0.02
20	+0.01	+0.05	+0.04	0.00	+0.07	+0.07
25	+0.28	+0.33	+0.05	+0.20	+0.13	−0.07
30	−0.04	+0.03	+0.07	+0.14	+0.10	−0.04
35	+0.27	+0.37	+0.10	+0.08	0.00	−0.08
40	+0.43	+0.34	−0.09	+0.06	+0.11	+0.05
45	+0.56	+0.57	+0.01	+0.05	0.00	−0.05
50	+0.37	+0.14	−0.23	+0.04	+0.07	+0.03
55	+0.43	+0.50	+0.07	−0.31	−0.28	+0.03
60	+0.57	+0.44	−0.13	−0.04	−0.09	−0.05
65	+0.56	+0.37	−0.19	−0.20	−0.11	+0.09
70	−0.18	+0.02	+0.20	−0.15	−0.13	+0.02
75	+0.42	+0.45	+0.03	−0.01	−0.06	−0.05
80	+0.21	+0.19	−0.02	−0.06	−0.02	+0.04
85	+0.40	+0.34	−0.06	−0.14	−0.14	0.00

The probable error of a difference for Circle A is ±0″.075, and for Circle B ±0″.039; in the mean ±0″.057. Under the assumption that the weight for 1895 is twice that for 1880, it follows that the probable error for 1880 is ±0″.047, and for 1895 ±0″.033, with the probability that these probable errors are larger for Circle A, and smaller for Circle B.

In view of all the evidence, the real probable error of the corrections deduced in 1895 for multiples of 20′ may safely be assumed to lie between ±0″.04 and ±0″.05.

Another point brought out by the comparison is the astonishingly small errors of graduation for Circle B. One might infer from the occurrence of the error −0″.28 at 55° that the lines for multiples of 10° were laid down first, and that the odd multiples of 5° were drawn in subsequently by bisection. This probability is somewhat strengthened by inspection of the corrections for Circle A. In a letter, of date April 13, 1861, Pistor and Martins state that such was the procedure they followed in the graduation of the circles for the Leiden Observatory (*Leiden Annals*, vol. I, p.ciii). If we suppose the errors of separate lines to be twice as great as for the mean of four microscopes, then it appears that the error committed in laying down the fundamental lines (multiples of 5°) for Circle B was in the mean only 0.38μ (or in inches, 0.000014); a fact which, in connection with a comparison of this circle with the best examples of the art of graduation that have been subjected to sufficiently accurate investigation, leads to the belief that the artist who graduated this circle was entitled to stand in the very foremost rank.

For Circle B there is no evidence of appreciable systematic error in the means of subdividing arcs of 5° into degrees; nor in Circle A is there any clear evidence to that effect, though the interval, 5° – 4°, appears to be too short in the mean by about 0″.2.

In the letter of 1861 to the Director of the observatory at Leiden, already cited, Pistor and Martins state that the subdivisions of the degrees on the Leiden circles was effected by means of a graduated scale (*Klappe*), one degree in length, which was copied. It is highly probable that the subdivision of degrees on the circles of the Pistor and Martins instrument here in question (which was made in 1856) was accomplished in the same way. The space from 0′ to 20′ for Circle A is, in the mean, 0″.026 too short; and for Circle B, it is 0″.042 too short. Small as these quantities are — they might with entire justice be termed insignificant — they appear to be real. The space, 40′–20′, upon Circle A appears, in the mean, to be too long by 0″.134; and the same space for Circle B is 0″.193 too long. 71 out of 90 spaces for Circle A, and 84 out of 90 for Circle B, confirm this conclusion. This fact was noticed before I had found out anything definite as to the methods of graduation which Pistor and Martins used; no one could have overlooked the facts, as presented in the computations. The evidence, in a condensed form, is presented in the following table, where the correction of the spaces, 20′–0′ and 40′–20′, are given for both circles in groups of ten.

Systematic Correction of 20′-Spaces.

	20′–0′		40′–20′	
R	A	B	A	B
° °	″	″	″	″
0–10	−0.05	+0.05	+0.01	−0.22
10–20	+0.02	+0.06	−0.16	−0.20
20–30	+0.07	+0.04	−0.07	−0.20
30–40	+0.02	+0.04	−0.18	−0.22
40–50	−0.04	−0.03	−0.15	−0.18
50–60	+0.15	+0.09	−0.10	−0.16
60–70	+0.05	+0.05	−0.08	−0.17
70–80	+0.03	+0.04	−0.26	−0.20
80–90	−0.02	+0.03	−0.20	−0.19

There is evidence here, not only of marvelous accuracy in copying single divisions, but also of most scrupulous fidelity in the general adjustments. For example, a shifting of the radial distance of the reference-points, on the scale to be copied, of no more than 0.02 mm, would be sufficient to alter the space 40′ 0′ by 0″.1. Of the individual spaces of 20′ measured on Circle B, 180 in number, and each really the mean of 4 spaces, the differences of 105 from the respective mean values were 0″.1, or less; for 54 were the differences between 0″.1 and 0″.2; for 16 between 0″.2 and 0″.3; and in only 5 instances did the space seem to differ by more than 0″.3 from its mean value. After making due allowance for the error of this investigation, I estimate the probable error of a space (mean of four spaces) in the subdivision of degrees, as laid down by Pistor and Martins to be ±0″.08. This leads to the conclusion that the probable error of copying for a single space was only ±0″.16, or in linear measure, 0.37μ; and that the copying error for a single line was ±0″.11, or ±0″.06 for the mean of four microscopes. This would mean that, whenever the constant correction due to the setting of the scale is known, as well as the absolute errors of the scale itself, the division-correction for any subdivision of a degree (mean of four microscopes) could be predicted with a probable error of ±0″.06.

As to the errors of the scale, or the systematic errors in the subdivisions of 20′, some slight evidence already exists. In 1880, the division-correction for every 2′ within the arc 37° 20′ to 42° 0′ of Circle A, and for the corresponding arcs in the other three quadrants, was determined with a fair degree of accuracy. In order to compare these results for ascertaining what testimony they offer in relation to systematic errors, I have referred the corrections in each degree to the mean of the 0′, 20′ and 40′ marks, — *i.e.*, the sum of the division-corrections for those marks has been made equal to zero. The first four columns of results in the table are the means of the outstanding corrections for the corresponding degrees in the four quadrants (as 38°, 128°, 218°, and 308°). In the last column of the subjoined table is given the mean of the 16 degrees, four in each quadrant; and the quantities in this column are attributable to the errors of the scale, so far as they are not the result of mere accident, either in copying the scale, or in the subsequent determination of the errors of the graduations. From the measures of 1895 just described, the corrections necessary to reduce the marks 0′, 20′ and 40′ to the zero assumed in the following table are respectively, +0″.04, +0″.08, −0″.12; by chance, the corrections found in the table are almost identical with these; and this, so far as it goes, indicates that the other numbers may not be wholly illusory.

Recurrence of Error within a Degree.

	38°	39°	40°	41°	Means
′	″	″	″	″	″
0	+0.01	+0.03	−0.04	+0.18	+0.04
2	+0.10	+0.24	+0.18	+0.09	+0.15

	38°	39°	40°	41°	Means
	″	″	″	″	″
4	+0.01	+0.08	−0.02	−0.22	−0.01
6	+0.09	+0.22	−0.03	−0.03	+0.08
8	+0.10	+0.04	+0.15	−0.09	+0.05
10	−0.15	0.00	−0.23	−0.50	−0.22
12	+0.09	+0.12	0.00	−0.15	+0.02
14	+0.13	+0.14	+0.02	−0.08	+0.05
16	+0.32	+0.24	+0.35	+0.15	+0.26
18	+0.56	+0.26	+0.23	+0.08	+0.28
20	+0.22	+0.04	+0.10	−0.03	+0.08
22	−0.04	−0.02	−0.01	−0.16	−0.08
24	−0.12	−0.19	−0.22	−0.26	−0.20
26	−0.13	−0.06	−0.18	−0.23	−0.15
28	+0.09	+0.12	+0.20	+0.07	+0.12
30	−0.19	+0.08	−0.02	+0.08	−0.01
32	−0.16	+0.13	+0.08	−0.04	0.00
34	−0.20	+0.11	0.00	−0.14	−0.06
36	−0.44	−0.16	−0.22	−0.33	−0.29
38	−0.29	−0.10	+0.05	−0.28	−0.16
40	−0.24	−0.08	+0.02	−0.13	−0.11
42	−0.30	−0.18	−0.04	−0.28	−0.20
44	−0.32	−0.32	−0.30	−0.33	−0.32
46	−0.52	−0.36	−0.37	−0.21	−0.37
48	−0.33	−0.13	−0.24	−0.12	−0.20
50	−0.68	−0.23	−0.40	−0.34	−0.41
52	−0.31	−0.15	−0.50	−0.34	−0.33
54	−0.51	−0.19	−0.38	−0.44	−0.38
56	−0.44	−0.02	−0.21	−0.31	−0.25
58	−0.28	+0.10	−0.42	−0.11	−0.18

The mean probable error of the numbers in the final column of the foregoing table is nominally ±0″.043; but the real probable error is very likely greater.

There were also other measures in 1880 of the space 50′-0′, at every multiple of 5° of Circle A, and for two such points on Circle B. In the mean of 20 spaces, each the mean of four quadrants, the relative correction of 50′, referred to 0′, is −0″.24; 15 out of the 20 measures gave negative determinations of this quantity, and the largest positive difference was +0″.13, the mean of the five being only +0″.06. Reduced to the zero of the foregoing table, the systematic correction for 50′, as here deduced, is −0″.20. If this be assigned the weight of 3 against unity for the value −0″.41 from the table, we have −0″.25 as the systematic correction for 50′.

I conclude that a scale was undoubtedly used in the subdivision of degrees on the Albany circles; that the same scale was used for both circles; and that it was copied with very great fidelity throughout. Were the errors of this scale known, in connection with the information we now have as to the errors for every 20′, I am convinced, that little occasion for apprehension as to the outstanding errors would remain. The systematic errors of subdivisions of a degree evidently deserve further attention.

The method here employed is probably more laborious than is the usual method for the same degree of apparent accuracy. Two observers, one for each circle, are practically necessary in the method pursued in the present investigation. In that method are to be feared torsion of the instrumental axis, differing strains and distortions upon the circles due to alterations in the temperature or to too rapid rotation of the circles, and possibly other sources of displacement or error, tending to change the observed relations of the circles to each other during the progress of a set. Errors of this description apparently presented themselves in some degree in the course of the present investigation; so that it became clearly advisable to move the instrument with the greatest delicacy and caution, and to limit the duration of a set to half an hour when practicable. On the other hand, these and other errors did not appear to be materially greater for sets twenty-five to thirty minutes long than they were for those of less duration.

In one sense, there is no special gain in knowing the flexures of the circles. For correcting measurements of zenith-distances, it is desirable to know the total effect of flexure, integrated for all the parts of the instrument; and, to be of value, the amount of this flexure must be ascertained by some method which determines at once the total resultant. Where there are two circles, however, this total flexure may be different, according as one or the other circle is used, and, therefore, the knowledge of the flexures of the circles is interesting and valuable as a check upon the measures of flexure in general.

On the other hand, the method employed in the present investigation seems to me to possess some decided advantages over the usual method. The most important of these advantages is that the investigation by the method here employed is carried out with the same microscopes, in the same adjustment, and with the same system of illumination, as in the ordinary use of the instrument. All who have attempted a thorough determination of division-correction will appreciate this point. A second important advantage of this method is found in the facility with which variation in the circumstances of determination for a particular arc, or series of arcs, can be devised and applied. Mere repetition, without variation of the process, in the measurement of these small quantities, is of little use. By judicious arrangements, in the employment of this method, the systematic accumulation of constant errors in the successive subdivision of arcs can be to a large extent avoided.

The principal sources of error in work of this kind are those arising from almost necessarily defective illumination of the circles, with which personal errors are also closely associated; those which originate in the defects of micrometers; and those which are due to changes of temperature. No claim to superior skill in dealing with these and similar sources of errors can be made for the present investigation; yet, with only a moderate degree of skill, the worst of the effects may be avoided. I am confident that the expectation of obtaining in the final results of any such investigation a degree of precision at all comparable to that which might have been predicted from the probable error of a single setting of the micrometer is sure to be disappointed. In the present investigation, the probable error of such setting averaged about 0″.18. Had this been the only source of error, the final results should have had less than half the probable errors that were actually found. At any one setting of the circles it was deemed quite sufficient to make two "bisections" in each microscope and to make these in successive rounds,—a plan which was uniformly followed throughout the work. One should always remember, also, that these complaints about inaccuracies and systematic errors really refer to very small linear quantities. The habit of dealing constantly with the second, and even the third, decimal of seconds in such investigations is misleading to the judgement. On our circles 0″.1 is only 0.23μ in linear measure; only about the one-thousandth part of the breadth of the vertical line in the figure, "1," here printed. A concrete view like this, after attentive consideration, may tend to restore the proper balance between over-sanguine and over-skeptical views.

This investigation has left an impression on my mind favorable to circles of larger diameters than those which are usually provided in connection with meridian instruments. The difficulties of ultimate accuracy in measurement upon the circles are essentially linear rather than angular. Two objections to large circles may have some force. The difficulty of securing homogenous construction, symmetry of form with equality in density and strength of the separate parts, may increase so fast with the radius, that the higher terms of flexure might become sensible. In my judgement, it makes very little difference whether this flexure is 0″.1 or 1″.0, so long as it accurately follows the theoretical law; and I should be inclined to believe that sufficiently perfect circles, in this respect, are within the compass of modern mechanical art, up to a radius of one meter at least. The second objection is, that large circles are inconvenient in the ordinary use of the instrument. This is an objection of some moment. As to the effects of change of temperature upon circles, it is difficult to see why they should be angularly larger for a large circle than for a small one. So far as the employment of meridian circles to measure the zenith-distances of celestial bodies is concerned, with careful usage, merely casual error of the circle-readings probably may not constitute a very important part of the entire casual error of observation. Therefore, the advantage to be gained from the larger circles must rest almost wholly upon the probability that, in comparison with small circles, their errors can be ascertained both with greater facility and with greater ultimate accuracy. From certain points of view, and for certain purposes, such determination of the correction for division-error may be considered desirable. This would be especially the case in fundamental work. For example: in certain relations of the Albany circles to the zenith, it is evident that a discussion of so-called "R—D" observations, or of "west—east" zenith distances, might result in conclusions altogether misleading, if the observations were not to be corrected for division-error, at least for the systematic part of it. Where many thousands of stars are to be observed within the limits of a narrow zone, the determination of the error for every line will be demanded and justified in the future progress of astronomy.

What has been attained in the present investigation would not have been possible without the cheerful and effective cooperation of the assistant observers, Arthur J. Roy, William B. Varnum, and John H. Ogburn. They all labored with a continually renewed personal zeal that prevented the work from degenerating into a profitless routine. Mr. Varnum performed with skill the larger part of the computations connected with the formation and solution of the equations. All the results were duplicated, or otherwise verified, by other computers.

SOUTHERN *ALGOL*-VARIABLES,

BY ALEX. WM. ROBERTS.

There are four *Algol*-Variables south of −30° at present known.

Chandler	Designation	R.A. (1900) h m s	Declination ° ′	Limits M M	Period d h m
3055	*X Carinae*	8 29 7	−58 53.2	7.90–8.65	0 12 59.5
3416	*S Velorum*	9 29 27	−44 15.9	7.85–9.25	5 22 24.3
5949	*R Arae*	16 31 26	−56 47.6	6.85–7.83	4 10 12.1
6546	*RS Sagittarii*	18 10 59	−34 8.5	6.60–7.70	2 9 58.8

Full elements of two of these, *S Velorum* and *RS Sagittarii*, have already been given in the *A.J.*, nos. 327, 349, 354 and 373.

I have delayed publishing elements of the remaining two, *X Carinae* and *R Arae*, in the hope that their variation would be independently confirmed by some southern observer.

As there seems little immediate prospect of this being done, I do not think any good purpose would be served by delaying longer. In this connection, however, I would desire to express my great indebtedness to Prof. Pickering, Harvard. With that generous willingness to assist which has placed many workers under great obligations to him, he undertook an examination of the Arequipa plates; an examination which resulted in the certain confirmation of the variation of *X Carinae* and *R Arae*.

The Arequipa measures are not numerous enough to confirm definitely either the period or the type of variation, and I would accordingly seek to bring before southern observers the clamant need that exists for independent examination of *X Carinae* and *R Arae*, as well as of the other interesting short-period variables south of $-30°$.

X Carinae, Ch. 3055.

Full period	$12^h\ 59^m\ 30^s.5$
Constant period	$6^h\ 20^m$
Limits of variation	$7^M.90$ to $8^M.65$
Epoch of minimum	1900 Jan. $1^d\ 3^h\ 10^m$ (Gr.M.T.)

The observations would seem to indicate that the several minima are alternately $8^M.65$ and $8^M.62$, and further that the brighter minima occur about two minutes nearer to the preceding faint minimum than to the succeeding one.

This apparent difference is, however, so slight, and the possibilities of systematic error in the determination of star-magnitudes so numerous, that I hesitate to consider it a real characteristic of the star's variation.

Such variation, if proved, would indicate that *X Carinae* is composed of two almost equal stars, which revolve round one another in practically a circular orbit in a period of $1^d\ 1^h\ 59^m\ 1^s$: the line of sight and the central line being nearly coincident.

R Arae, Ch. 5919.

Full period	$4^d\ 10^h\ 12^m\ 7^s.5$
Constant period	$4^d\ \ 1^h$
Limits of variation	$6^M.85$ to $7^M.83$
Epoch of minimum	1900 Jan. $5^d\ 7^h\ 38^m$ (Gr.M.T.)

The limits of variation given, $6^M.85$ to $7^M.83$, are the mean limits. Minima have been observed, however, as high as $7^M.70$, and as low as $8^M.00$, and under conditions which preclude the possibilities of relative position influencing the determination.

The light-curve is symmetrical on each side of the minima, an expression of the form

$$(7^M.83 - m_0) = a + bt + ct^2$$

satisfying the variation before and after minimum.

Attention may be called to the change introduced in reckoning the epoch of minimum phase. The first minimum of 1900 is taken as the reference-date. I intend to adopt in future the same principle in dealing with the other southern variables regularly observed here, and it would secure uniformity if future corrections to the time of minimum epoch of *Algol*-Variables, or the time of maximum epoch of short-period variables south of $-30°$, were made on this date.

OBSERVATIONS OF VARIABLE STARS, 1895–1896.

BY PAUL S. YENDELL.

678. *U Persei.*

A series of thirty-one observations of *U Persei*, extending from 1895 Sept. 15 to 1896 April 16, is of interest as possibly throwing some light on the discordances and disagreements between the observations of different observers, and the nature of the large irregularities noted in the remark on this star in CHANDLER's Third Catalogue.

In reducing these observations, a careful revision of the entire light and magnitude-scales was made. The resulting light-values, when plotted, showed a very curious curve, having three distinct crests, with two decided depressions between them, as follows: a crest of $8^M.2$ on 1895 Nov. 30, a depression of $9^M.2$ on Dec. 15, a crest of $8^M.2$ on Dec. 31, a depression of $9^M.2$ on 1896 Jan. 13, and a crest of $9^M.1$ on Jan. 30.

These fluctuations seem to be of altogether too great amplitude to be attributed to errors of observation, and any one of the crests would have been taken for the maximum if from any cause the others had been missed; and this appears to have been the rule in the maxima previously observed by myself.

To ascertain whether the occurrence of these fluctuations presented any approach to regularity, I re-reduced all my observations of the star, about a hundred and twenty in all, and assembled them in a mean light-curve, using the elements given by CHANDLER in his Third Catalogue. The normals formed from the groups of five observations each, upon being plotted, show a crest of $8^M.46$ on the fiftieth day before the computed date of maximum, a depression of $8^M.76$ on the thirty-second day before, a second crest of $8^M.40$ on the second day before, a second depression of $8^M.80$ on the twenty-second day after, and a third crest of $8^M.50$ on the forty-second day after; the rise before the first crest and the decline after the third being rapid and uninterrupted. The date of maximum indicated by a general curve which smooths out these fluctuations falls on the sixth day before the computed date.

A general curve drawn in the same manner through the observations of 1895–1896, indicates a maximum on 1895 December 24.

It would appear from the above, that in the present state of our knowledge of this star no series of observations extending over less than five months can be considered of value, and that the only safe course will be to begin the series as soon as the star becomes visible, and continue them until it again disappears.

1981. *S Camelopardalis.*

Twenty-one observations of this star, from 1895 October 18 to 1896 May 12, indicate a maximum of about $8^{M}.1$, on 1896 February 3.

2080. *R Columbae.*

I have observations of this star on five dates in March 1895, from the sixteenth to the twenty-first inclusive. From the low southern declination of the star, the comparisons were difficult and uncertain, and are of value only as showing that the star was then visible and certainly identified as Hartwig's star. The magnitudes deduced from comparisons with C.DM. $-29°2450$, $9^{M}.1$, were from $9^{M}.4$ to $9^{M}.5$.

Observations were also obtained on 1895 Nov. 29, and Dec. 19, 20, and 22, the estimates being $9^{M}.3$ and $9^{M}.4$. The star was looked for and not seen on 1896 Jan. 11 and 16, Feb. 1 and March 7, the limit of vision being in each case the tenth-magnitude stars of the Cordoba DM. On every one of the dates above given, the place given by Pickering, south preceding the variable which was observed, was scrutinized with care, and in no case was any star seen there so bright as the tenth magnitude, which appears to be the usual limit of vision for my eye and telescope in this region.

2100. *U Orionis.*

My first observation of *U Orionis* at the recent maximum was made on 1895 Dec. 22, the star being then very faint, and estimated to be not brighter than the 10½ magnitude. A maximum of $6^{M}.8$ is indicated by my observations on March 19; and at the last observation, May 7, it had decreased to $7^{M}.8$. The observations number twenty-two.

3425. *X Hydrae.*

My first observation of this star during the present season was made on 1896 March 17, when its light was estimated at $9^{M}.0$. It increased rather rapidly to a maximum April 8, when it was estimated to be of $8^{M}.3$. Its decrease was at first rapid, and afterwards slower; and at the last observation, on May 16, it had fallen to $9^{M}.1$. There are fifteen observations in all.

3825. *R Ursae Majoris.*

Eighteen observations of *R Ursae*, from 1896 March 12 to May 27, indicate a maximum on April 7. When first observed it was of about $7^{M}.9$, its brightness at maximum being $7^{M}.2$, and at the last observation $9^{M}.4$.

4816. *V Virginis.*

I have nineteen observations of *V Virginis* between 1896 May 4 and July 11, since which latter date it has been impossible to obtain a useful observation of the star. A maximum of $9^{M}.1$ is rather uncertainly indicated about June 15 — the star's light when last observed having decreased only about $0^{M}.3$.

4847. *S Virginis.*

The first observation of this star during the present season was made on 1896 April 8, when it was found at $9^{M}.8$. Its rise was rapid and regular, and a well-defined and bright maximum was passed on June 3, at which time the star's estimated brightness was $6^{M}.7$.

Its decline was rather slower, and when last seen, on July 23, its brightness was estimated as $8^{M}.1$.

5190. *R Camelopardalis.*

I began observations of this star on 1896 Feb. 16, the star's light on that date being about $9^{M}.5$. From that date to July 25, I observed the star twenty-five times, it being invisible at the last observation, in a clear sky in bright moonlight. At the previous observation, on July 12, its light was estimated at $8^{M}.4$.

A maximum of $7^{M}.8$ is indicated on May 23.

5438. *Y Librae.*

Eleven observations of this star, from 1896 May 12 to July 11, indicate a maximum of $8^{M}.7$ on June 9. The star's light at the first observation was estimated at $9^{M}.8$, and at the last at $9^{M}.2$.

5501. *S Serpentis.*

I have twenty observations of this star, from 1896 April 29 to July 25. When first seen it was of 11½ magnitude, by a careful eye-estimate. It increased steadily to a maximum of $7^{M}.8$, which is indicated on 1896 June 24, and has since declined to $8^{M}.7$.

5675. *V Coronae.*

This star was observed, from 1896 April 8 to July 18, seventeen times. When first observed, its light was estimated at $9^{M}.6$. It increased to $8^{M}.6$, passing a maximum about May 8, after which date it decreased to $10^{M}.5$, its estimated brightness at the last observation.

7502. *X Delphini.*

I have seven observations of this star, fully confirming its variability, and showing a well-defined maximum on 1896 June 8.

At the first observation, 1896 May 13, the estimated magnitude was $9^{M}.7$; at the next observation, June 2, it had increased to $8^{M}.7$, and on June 10 to $8^{M}.6$. From this date it fell off steadily to $9^{M}.7$, its estimated brightness on July 17. When next looked for, on July 30, it had disappeared, the estimated limit of vision at the time being $11\frac{1}{2}^{M}$. A reduction of Anderson's observations published in No. 3314 of the *Astronomische Nachrichten*, indicates a maximum on 1895 Sept. 2, so that the star's period is probably approximately $\frac{280\,d}{n}$.

Dorchester, Mass., 1896, *August* 6.

Z CENTAURI AND THE NEBULA SURROUNDING IT.

BY WILLIAM J. HUSSEY.

Estimates of the brightness of this star in December, January and February are given in *Astr. Jour.*, no. 371. Since then I have made observations as follows:

1896 June	11	$14.4^{\rm M}$
	26	$15\frac{1}{4}$
July	9	16 nearly

The comparison-stars were estimated as follows: *D*, $14\frac{1}{4}^{\rm M}$, situated between *A* and *B*, somewhat nearer *A*; *E*, $15\frac{1}{2}^{\rm M}$, at somewhat unequal distances from *B* and *D*, and slightly north of the line joining them: *F*, $16\frac{1}{4}^{\rm M}$, between *A* and *D*. *A* and *B* are the stars denoted by the same letters in *Astr. Jour.*, no. 371.

The star *Z Centauri* is surrounded by a faint, irregular nebula, which extends continuously to the large and bright nebula N.G.C. 5253, and of which it seems to be a part. When the star was brighter, the nebula about it was not seen; this was, no doubt, due to the overpowering light of the star, for as the star faded the nebula became more and more conspicuous. The nebula was first seen on June 11, 1896.

Mt. Hamilton, Cal., 1896 *August* 16.

COMET 1896 *c* (1889 V).

NOTE AND EPHEMERIS BY CHARLES LANE POOR.

The observations made at the Lick Observatory, during the early part of July, enabled me to make a careful determination of the elements of this comet. For the purpose of correcting my old elements a normal place was formed for July 17.5 Greenw. mean time, at which date the comparison of the observations with the ephemeris gave me

$$\text{O}-\text{C} \quad \Delta\alpha = -30^{\rm s}.99$$
$$\Delta\delta = -\ 3'\ 38''.5$$

In forming these differences the perturbations were taken into account.

From these differences the value of the indeterminate, ν, was then found to be as follows:

$$\text{From} \quad \Delta\alpha \quad \nu = -3.757$$
$$\Delta\delta \quad \nu = -3.542$$
$$\text{Mean value} \quad = -3.650$$

This agrees so well with my former determination, −3.66, from a comparison with the observation of June 20, at Nice, that I have made no change in the elements given in my former note. Those elements give me for July 17.5 the following:

$$\text{O}-\text{C} \quad \Delta\alpha = -0^{\rm s}.96$$
$$\Delta\delta = -0''.45$$

I append an ephemeris computed from the elements, corresponding to $\nu = -3.66$, as given in my former note.

Gr. M.T.	App. α	App. δ	log Δ
	h m s	° ′ ″	
Sept. 1.5	22 20 9.1	−19 8 0	0.01488
5.5	17 25.4	4 29	0.01513
9.5	14 58.8	−18 57 22	0.01686
13.5	12 46.4	47 15	0.02002
17.5	10 57.3	33 44	0.02445
21.5	9 28.7	17 25	0.02999
25.5	8 31.1	−17 57 48	0.03467
29.5	8 1.5	35 8	0.04418
Oct. 3.5	8 2.5	9 37	0.05276
7.5	8 35.6	−16 41 23	0.06199
11.5	22 9 41.1	−16 10 26	0.07185

NEW ASTRONOMICAL WORK.

Publicationen der v. Kuffner'schen Sternwarte in Wien, Band IV. Dr. LEO DE BALL.

At the present time the chief undertaking of v. KUFFNER'S Observatory in Vienna is the observation of the *Gesellschaft*-zone included between the parallels of −5° 50′ and −10° 10′ of declination; and this volume contains the results for the zones 90 to 244. The resulting star-positions for 1900 are given in a later section of the work in a form convenient for reference. This volume also contains a description of the new transit-instrument to be used in the prime vertical, and of the new heliometer, as well as of the structures arranged for the reception of those instruments. An appendix contains an elaborate discussion of the orbit of the Comet 1882 III by Dr. DE BALL.

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NEW ASTRONOMICAL WORK.

PUBLISHED IN BOSTON, TRI-MONTHLY, BY B. A. GOULD. ADDRESS, CAMBRIDGE, MASS. PRICE, $5.00 THE VOLUME. PRESS OF THOS P. NICHOLS, LYNN, MASS.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed Sept.* 2.

THE

ASTRONOMICAL JOURNAL.

No. 384.

VOL. XVI. BOSTON, 1896 SEPTEMBER 17. NO. 24

LAC. 5861: SHORT-PERIOD VARIABLE, CLASS II,

By ALEX. WM. ROBERTS.

The new short-period variable in *Centaurus* recently announced in the *A.J.*, no. 378, is one of considerable interest, as its type of variation is quite distinct from that of the other short-period variables discovered here. Its ascending period is almost exactly of the same duration as the descending period, a fact which relates the star indirectly to those of the *Algol*-type, and directly to *U Pegasi*. This is of extreme importance, as it materially strengthens the opinion expressed by Dr. CHANDLER that *U Pegasi* probably belongs to a new type of short-period variable (*A.J.*, no. 374). While drafting out this paper, there has just reached me the announcement by Prof. PICKERING that he finds that *S Antliae* is not an *Algol*-variable, but a short-period variable of this new type, which for brevity we may call Class II, — the ordinary short-period variables, of which δ *Cephei* may be taken as the type, forming Class I.

This discovery is in every way important, as it indicates a second marked characteristic of this type, viz.: rapid variation within narrow limits.

This second characteristic is quite as pronounced a feature of the three stars belonging to this class as the characteristic first referred to, for we have

Star	Period	Ampl. of Variation
	h m	M
S Antliae	7 46.8	0.60
Lac. 5861	7 16.0	0.34
U Pegasi	5 32.4	0.65

The star that comes nearest to these in shortness of period is *R Muscae*, but its period is 21 hours. Thus there seems a distinct gap between the periods of Class II, and those of Class I. The mean period of 14 southern short-period variables belonging to Class I, is 4.5 days; the mean period of the three stars belonging to Class II is about 7 hours.

The narrowness of the limits, between which these stars vary, leads naturally to another question, and one which is in reality the main purpose of this paper to deal with, viz.: what is the accuracy attainable in the determination of the magnitudes of stars. For, if a narrow amplitude of variation is common to all stars of this class, it is more than probable we shall have variation of $0^{M}.2$ or even $0^{M}.1$, and it becomes a serious question if our present accuracy in estimating star-magnitudes will respond to such variation. I think it will, and after dealing with the variation of Lac. 5861, I purpose proving that with care and foresight as regards the elimination of errors, and reduction of results, an accuracy of at least $0^{M}.03$ can be secured in the determination of relative magnitudes by the method of sequences.

Over 400 observations of Lac. 5861 have been made at Lovedale since the beginning of May, the usual method adopted being to begin observations soon after dark, and to continue them at intervals of 20 or 30 minutes for about six or eight hours.

That there might be no bias as to the times of maxima or minima, no ephemeris of any kind was constructed. Following out the principle of work adopted here, each observation is the mean of two, one direct and the other reverse. The same comparison-stars were always used, and the measures were reduced to a common standard by a simple method that will immediately be referred to.

The observations in July were made with the greatest care, the narrow limits of variation, $0^{M}.34$, demanding the most extreme care as to the position of the head, height of the telescope, and similar fruitful sources of error.*

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*In two essential particulars I find myself at utter variance with astronomers whose reputation is assured, and on whose judgement I would naturally implicitly rely. To estimate rapidly is, in my case, to estimate badly, and consequently I take sometimes as long as five minutes to a single observation. Then again I always endeavor to have the variable and the comparison-star in the same field, so that I may estimate both *at the same time*.

The determinations of maxima and minima are as follows:

Obs.	Maxima			Minima			Limits
		h	m		h	m	M M
18	1896 May 7	6	15	May 7	10	0	7.50 – 7.78
9	12	10	10	12	6	15	7.51 – 7.80
16	13	7	22	13	11	7	7.53 – 7.83
16	14	12	32	14	8	30	7.46 – 7.77
15	15	10	37	15	6	37	7.46 – 7.85
11	. . . .			17	10	7	7.80
14	18	11	7	18	7	6	7.44 – 7.83
15	19	9	30	19	13	0	7.47 – 7.79
11	20	7	15	20	10	37	7.51 – 7.77
12	. . . .			21	7	15	– 7.84
20	22	10	15	22	6	10	7.40 – 7.77
14	23	7	22	23	10	33	7.54 – 7.77
16	June 9	13	15	June 9	9	45	7.48 – 7.80
19	17	10	52	17	7	8	7.43 – 7.77
9	28	8	30	. . . .			7.46 –
12	29	6	15	29	10	0	7.54 – 7.79
23	July 1	8	50	July 1	12	30	7.44 – 7.88
23	5	7	22	5	11	7	7.36 – 7.83
25	6	12	22	6	9	7	7.47 – 7.78
22	8	7	56	8	11	30	7.37 – 7.84
23	13	11	15	13	7	45	7.43 – 7.74
22	14	9	15	14	13	7	7.44 – 7.84

The following are the elements of variation resulting from the preceding times of maxima and minima.

Period	$7^h\ 16^m$
Epoch of max.	1896 May $7^d\ \ 6^h\ 23^m$ (C.M.T.)
Epoch of min.	$7^d\ \ 9^h\ 58^m$
Mean limits of variation	$7^M.47$ to $7^M.81$

An inquiry as to the amount of confidence to be placed in this result must of necessity begin and end with the accuracy attainable in determining the relative, and consequently the absolute, magnitudes of the stars made use of in the investigation.

The comparison-stars used were

		h m s	° ′ ″	
(1)	Cord. Z.C. XIV. 259	14 3 57.6	–57 43 39	(1875)
(2)	505	7 48.1	56 12 45	
(3)	512	7 51.1	57 44 29	
(4)	639	9 56.8	58 6 21	
(5)	837	14 13 8.0	–57 42 58	

Let $M_{(1)} + M_{(2)} + M_{(3)} + M_{(4)} + M_{(5)} = N$ be the magnitudes of the five comparison-stars, as determined by sequences from $6^M.8$ and $9^M.3$ at a single observation, N being the sum total of the five magnitudes.

Let M_v be the magnitude of the variable as determined with relation to the five comparison-stars.

Let K be the mean of all the values of N; in the present instance the constant quantity, 37.70.

Then to reduce the magnitudes of the comparison-stars to standard values, the correction $\frac{37.70 - N}{5}$ will have to be applied to each star.

The same correction will be applied to the apparent magnitude of the variable, which therefore becomes

$$M_v + \frac{37.70 - N}{5}.$$

In this way each observation is reduced to a common standard.

It would overburden the present paper to give *in extenso* the whole of the observations so reduced; it will be sufficient to deal in this way with the observations of one night only, say those of July 1.

The following magnitudes are reduced to standard values, as it will be noticed the sum total of the magnitudes of the five comparison-stars is equal to 37.70.

1896 July 1.

Hour Cape M.T.	Comparison-Stars					Variable		O—C
	Z.C. 505	Z.C. 639	Z.C. 259	Z.C. 837	Z.C. 512	Obsd	Comp.	
h m	M	M	M	M	M	M	M	m
6 0	7.33	7.48	7.53	7.53	7.83	7.78	7.81	–0.03
30	.25	.45	.65	.50	.85	.70	.72	–0.02
7 0	.30	.45	.60	.50	.85	.70	.62	+0.08
10	.23	.38	.73	.53	.83	.63	.60	+0.03
25	.22	.37	.77	.47	.87	.52	.56	–0.04
45	.22	.42	.67	.52	.87	.47	.51	–0.04
8 0	.30	.45	.65	.55	.75	.50	.48	+0.02
15	.27	.42	.62	.52	.87	.47	.46	+0.01
30	.27	.47	.62	.52	.82	.42	.44	–0.02
50	.30	.45	.55	.50	.90	.45	.44	+0.01
9 10	.34	.44	.54	.49	.89	.44	.44	0.00
30	.28	.43	.58	.58	.83	.46	.47	–0.01
50	.27	.42	.57	.57	.87	.45	.50	–0.05
10 15	.25	.40	.60	.60	.85	.55	.56	–0.01
33	.25	.30	.65	.65	.85	.70	.62	+0.08
50	.23	.38	.63	.63	.83	.63	.68	–0.05
11 15	.27	.47	.52	.62	.82	.77	.76	+0.01
30	.32	.47	.52	.57	.82	.77	.80	–0.03
12 0	.34	.39	.54	.54	.89	.89	.87	+0.02
30	.32	.42	.57	.52	.87	.87	.88	–0.01
50	.32	.42	.52	.52	.92	.92	.86	+0.06
13 20	.39	.44	.49	.49	.89	.74	.80	–0.06
13 45	7.28	7.53	7.53	7.48	7.88	7.68	7.72	–0.04

Mag. of Cord. Z.C. 505	$7^M.29$	Average error	$\pm 0^M.036$
639	7.43		.034
837	7.54		.036
259	7.59		.060
512	7.85		.030

The star Z.C. XIV. 259 seems to vary through $0^M.2$: leaving it out of account, the average departure of any determination is thus only $0^M.034$. It may be urged that this agreement is only apparent; that the mind is always influenced in the direction of making accordant determinations. This objection is not valid where two observations are made, as the values of each observation are different, the constant altering of the positions of the stars affecting both the direct and reverse observations. Further, observations of other variables were taken concurrently, so that as much as possible the mind might be left free to make independent judgements.

It has already been stated that more care was taken during the July determinations.

It is unnecessary to give in detail the observations made on July 5, 6, 8, 13, 14. They were made exactly on the same plan as those of July 1. It is of importance as dealing directly with the question at issue, viz.: the accuracy attainable in determinations of stellar magnitudes by sequences to give the values of the five comparison-stars made on the six nights in July.

No. of Obsns	Date 1896	Z.C. 505	Z.C. 639	Z.C. 837	Z.C. 259	Z.C. 512
		M	M	M	M	M
23	July 1	7.29	7.43	7.54	7.59	7.85
23	5	.28	.41	.57	.59	.85
25	6	.26	.39	.58	.61	.86
22	8	.26	.37	.58	.61	.88
23	13	.25	.40	.55	.64	.86
22	14	7.25	7.39	7.56	7.62	7.88

		M	M
Mean magnitude of Cord. Z.C.	505	7.26	±0.012
	639	7.40	.015
	837	7.56	.013
	259	7.61	.013
	512	7.87	.013

It is therefore possible, I hold, to determine by sequences the magnitudes of any system or group of stars with an accuracy greater than $0^{M}.05$, when only a few isolated observations are taken, and with an accuracy greater than $0^{M}.02$, when a fuller series of observations is made.

The mean values of the comparison-stars afford sufficient proof for this contention, and will no doubt be considered strong evidence for the possible attainment of such accuracy as two or three-hundredths of a magnitude.

A much more important, and less questionable, line of evidence would be to deal with the variable itself. Here we cannot be influenced by mental bias, for there is no previous knowledge of the variation of the star at any time.

Reverting again to the observations of July 1, if the variation be regular the mean curve will be of the form

$$x + \alpha \cos(\theta - M) + \beta \cos(2\theta - N)$$

where $\theta = (T - 8^{h}\,50^{m})\,0^{\circ}.8257$

T being the time of observation, and $(T - 8^{h}\,50^{m})$ a quantity expressed in minutes.

We have, from the 23 observations taken on July 1, 23 equations of condition of the form

$$x + \alpha_1 \cos\theta + \beta_1 \sin\theta + \gamma_1 \cos 2\theta + \delta_1 \sin 2\theta = M,$$

where

$$\alpha_1 = \alpha \cos M$$
$$\beta_1 = \alpha \sin M$$
$$\gamma_1 = \beta \cos N$$
$$\delta_1 = \beta \sin N$$

Solving rigorously the following are the values obtained for the form of the light-curve of Lac. 5861 on July 1.

$$7^{M}.646 - 0^{M}.223 \cos(\theta - 357^{\circ}\,37') - 0^{M}.014 \cos(2\theta - 156^{\circ}\,44')$$

The computed values from this expression are given in the table of observations of July 1 under the heading "Variable: computed," and it will be seen how closely the curve, obtained analytically, represents the observed values.

The average error of a single observation is only $\pm 0^{M}.032$, and when we compare this with the average error as determined over six nights in July from comparison-stars, viz.: $\pm 0^{M}.033$, we must admit that this value represents the accuracy attainable by the method adopted at Lovedale.

If we take into consideration only the observations taken with the reversing eye-piece, the average error is $\pm 0^{M}.08$, and with the direct vision eye-piece, $\pm 0^{M}.09$.

The advantage, therefore, of taking two observations and combining them is indisputable.

To refer again to the expression obtained for the light-curve of Lac. 5861, it is evident that if it be possible to represent in definite trigonometrical terms the law of variation of stars belonging to this new class, we have at once a means of obtaining the elements of variation that is superior to the method usually adopted of comparing maxima and minima points obtained graphically. The elements of Lac. 5861 given in this paper have indeed been obtained graphically, but I have never felt perfectly satisfied with this, or with other similar results, so determined; and I intend, when a definitive solution of the elements is sought, to adopt the more rigorous, but more laborious, method of procedure.

REPLY TO AN ARTICLE BY MR. YENDELL IN *ASTR. JOURNAL* No. 380,

By N. C. DUNÉR.

Mr. P. S. Yendell has raised some objections to the manner in which I have used his observations of *Z Herculis*, published in no. 366. In part Mr. Yendell considers that I have treated his observations of magnitude of both the minima of the star in a "summary manner," inasmuch as I have designated as "erroneous" so small a difference as $0^{M}.2$ between the even and uneven minima. In no. 366, Mr. Yendell gives no information as to the maximum magnitude which he assumed for the star; and since the amplitude (magnitude at maximum — principal minimum) amounts to nearly a full unit of magnitude, I have been obliged to assume that Mr. Yendell had put this certainly not lower than $7^{M}.0$. My remark was directed against the assumption of an amplitude of $0^{M}.95$ for the even minima, but so great as $0^{M}.75$ for the uneven ones.

It is true that, in no. 380, Mr. Yendell says that he employed the photometric measures of Muller and Kempf, which give the normal magnitude of *Z Herculis* as $7^{M}.45$. According to this, the amplitudes would be respectively $0^{M}.65$ and $0^{M}.15$. In both cases, however, the latter amplitude would be much too large relatively, and the former too small absolutely.

Mr. Yendell moreover censures my mode of computing the observations of *Z Herculis*, inasmuch as he considers that my elements can in no way be regarded as definitive, since I took no account of Muller and Kempf's measurements of the brightness. That I made no claim whatever to have furnished definitive elements must be sufficiently evident from the fact that I did not once take any account of the light-equation. Moreover, isolated incomplete observations can only be used when long series of observations are available, since one cannot otherwise know whether the same were made before or after the minima, and it is also not beyond doubt that they may be affected by large accidental errors. What I desired to do was only to prepare an ephemeris for the next appearance; and Mr. Yendell's observations seem to prove that I succeeded very well in this.

First of all, it has displeased Mr. Yendell that I designated his secondary epoch of minimum 1895 April 23 as "evidently erroneous," and have excluded this: he asserts, indeed, that I have chosen this expedient as an "easy and convenient manner to dispose of an observation which does not confirm one's own theory." This is about equivalent to accusing me of an intentional scientific falsification. Mr. Yendell should not have done this, but rather have simply made the computation. If he had done so, he must have found that the total deviation from my ephemeris of the mean *of all his observations of the uneven minima* (without exclusion) only amounts to -17^{m}, so that it agrees with the same far more closely than I could have hoped, in view of the small number and great uncertainty of the autumn observations; and consequently that there existed absolutely no ground for excluding this observation, for the reason given by Mr. Yendell. On the other hand there do exist purely objective scientific grounds for this course. For, if we take the mean of the discordances between Mr. Yendell's observations of the "uneven minima," and my ephemeris, we obtain, as I have said, -17^{m}, and accordingly $\pm 22^{m}$ as the probable error of a single observation. But then the first observation would be rejected by Peirce's criterion. In this process, there is nothing arbitrary, except the assumption that the discordances after subtracting the -17^{m} are entirely accidental. But I do not see that in a preliminary computation of a star belonging to the *Algol*-type, any other assumption is justifiable. At any rate, it is much bolder to introduce, as Mr. Yendell does, a term of the third order, relatively to the time ($-0^{r}.0012\,E^{3}$).

Nevertheless, I will not further contend with Mr. Yendell as to the rejection or acceptance of this observation. Much more would it gratify me, and for good reasons, if he could defend his observations of the "uneven minima" against the attacks of an entirely different sort, which are soon to be brought against them. Prof. Pickering has already communicated to the "*Astrophysical Journal*" (April, 1896), that on September 10, from 13^{h} to $15^{h}\,56^{m}$ Greenwich M.T., he perceived no variability in *Z Herculis*. Accidentally this communication came for the first time to my hands in July, and consequently I could take no account of it in my article in no. 374 of the *Astronomical Journal*. But later Prof. Pickering has communicated to me, by letter, that likewise Sept. $14^{d}\,13^{h}\,51^{m}$ to $17^{h}\,35^{m}$, Sept. $30^{d}\,12^{h}\,37^{m}$ to $16^{h}\,8^{m}$, and Oct. $8^{d}\,13^{h}\,35^{m}$ to $15^{h}\,10^{m}$ he always saw the star at its maximum brilliancy: and thence draws the inference that in 1895, in general, no "secondary minima" occurred. If now all Mr. Yendell's eight observations made under favorable circumstances must be rejected, I should scarcely dare to assert that my three observations, made under unfavorable circumstances, namely in part in very bright twilight, might not also be incorrect; and I should therefore much prefer to declare the theory which I have proposed, to be entirely undemonstrated, than to defend it, as Mr. Yendell supposes, in every manner, even by unpermissible methods. For, as I have already declared in no. 374, I cannot but see in Mr. Yendell's observations a very fine and welcome proof of this theory. If these observations are to fall, the theory itself must therefore also be regarded as seriously shaken.

Upsala, 1896 August 3.

PROJECTION ON THE TERMINATOR OF *MARS*.

By W. J. HUSSEY.

This morning (Aug. 27, $16^{h}\,15^{m}$) I observed a bright projection on the terminator of *Mars* at about 50° south latitude and 275° longitude. This position locates the projection in or very near the white region called *Chersonesus* on Schiaparelli's map of *Mars*. Similar projections were observed here in 1890, 1892 and 1894. This is the first one seen at this opposition.

Mt. Hamilton, Cal., 1896 Aug. 28.

NOTES ON VARIABLE STARS,—No. 14,

By HENRY M. PARKHURST.

Third Catalogue. CHANDLER'S Third Catalogue, *A.J.* 379, will now be the standard for reference in the column of corrections; but to connect with my former results, the correction in using the former elements will be given in parentheses in the column of remarks.

R Comae. The shortening of the period, showing approaching recession from the twilight, is now evident. The following sine-formula rejects the inconsistent observation of 1856, representing all the others with an average deviation of less than a day.

$$2389892.9 + 361.8\,E + 40^{d}(\sin 4°.0\,E + 114°).$$

Y Bootis. I have only succeeded in observing five minima, none fully satisfactory. The times given are independent of the prediction; but the period has been adjusted since the last observation, for the purpose of comparison. Rejecting the sine-formula, *A.J.* 329, and adopting YENDELL'S observation for the epoch, the most probable elements are, 2948.623 + 2.6046. The corrections in the table result from comparison with these elements.

Comparison-Stars. The differential positions of comparison-stars, given to tenths of a minute of arc, were kindly furnished me for this and subsequent numbers of the Notes, by J. A. PARKHURST, of Marengo, Ill.

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date Julian	Observed Date Calendar	E	Corr.	W	Remarks
				1895-6				
3170	*S Hydrae*	Min.	3622:	Mar. 3	56	–	1	Probably earlier
3184	*T Hydrae*	Max.	3603.6	Feb. 13	48	+ 2	9	(—22). Approx. agreement with last year
3186	*T Cancri*	Min.	3611	Apr. 11	29	— 23	7	
3264	*W Cancri*	Max.	3611	Feb. 21	4	+ 12	3	
3425	*X Hydrae*	Max.	3659	Apr. 9	5	— 1	9	
3477	*R Leonis min.*	Min.	3633	Mar. 14	31	+ 29	3	Inconsistent with observations of last year
3493	*R Leonis*	Max.	3571.7	Jan. 12	162	— 9	9	(—37). Brightn. corresponds with that two years [ago; *A.J.*, 326
3881	*V Hydrae*	–	–	–	–	–	–	Apparently irregular
3890	*W Leonis*	Max.	3510	Nov. 12	22	–	0	Predict'n from my ele., *A.J.*, 300. Obs. not incons.
3994	*S Leonis*	Max.	3631	Mar. 12	68	— 43	3	Correction apparently increasing
4315	*R Comae*	Max.	3777.4	Aug. 5	66	+0.3	9	(—1.3). Compared with ele. given in note above
4407	*R Corvi*	Max.	3662.9	Apr. 12	32	— 5	9	(+16). Brighter than last year
4492	*Y Virginis*	Max.	3706	May 26	22	+ 13	9	Very slow descent
4596	*U Virginis*	Min.	3661	Apr. 11	53	–	0	From elements: probably more than 7 days earlier
4816	*V Virginis*	Max.	3743.1	July 2	53	+ 10	9	
4847	*S Virginis*	Max.	3709.2	May 29	43	0	9	
4948	*R Can. Ven.*	Max.	3768	July 27	9	+ 8	9	
5070	*Z Virginis*	Max.	3697.4	May 17	19	+ 13	9	(+41). Confirms correction of last year
5144	*Y Bootis*	Min.	3633.625	Mar. 14	263	—.008	1	The lowest of nine observations. See note above
"	"	Min.	3680.526	Apr. 30	281	+.009	2	The first observations of the series
"	"	Min.	3693.539	May 13	286	—.001	2	From the first two observations
"	"	Min.	3706.598	May 26	291	+.035	3	Cloudiness
"	"	Min.	3758.613	July 17	311	—.042	5	Time from the smoothed curve
5174	*RS Virginis*	Max.	3662	Apr. 12	6	— 8	6	Double max.; shown also last year

INDIVIDUAL OBSERVATIONS.

3170 *S Hydrae.*

(Continued from 350.)

Julian	Calendar	Mag.
	1896	
3601.5	Feb. 11	11.7]
3624.5	Mar. 5	11.9
3627.5	8	11.8
3633.5	14	11.7
3652.6	Apr. 2	11.30_2

3184 *T Hydrae.*

(Continued from 350.)

Julian	Calendar	Mag.
	1896	
3577.6	Jan. 18	8.29_2
3586.6	27	9.12_2

3184 *T Hydrae.*—Cont.

Julian	Calendar	Mag.
	1896	
3592.6	Feb. 2	8.25
3597.6	7	8.36_2
3609.6	19	8.20_2
3627.6	Mar. 8	8.89_2
3632.6	13	8.74_2
3639.6	20	8.63_2
3646.6	27	9.12_2

3186 *T Cancri.*

(Continued from 350.)

Julian	Calendar	Mag.
	1896	
3640.6	Mar. 21	9.79_2

3186 *T Cancri.*—Cont.

Julian	Calendar	Mag.
	1896	
3650.6	Mar. 31	9.69_2
3658.6	Apr. 8	9.83_2
3665.6	15	9.1P
3679.5	29	9.59_2
3686.6	May 6	9.65_2
3687.6	7	9.3P
3693.6	13	9.31_2

3264 *W Cancri.*

Julian	Calendar	Mag.
	1896	
3573.6	Jan. 14	10.9
3604.6	Feb. 14	9.32_2

3264 *W Cancri.*—Cont.

Julian	Calendar	Mag.
	1896	
3627.5	Mar. 8	9.60_2
3633.6	14	9.86_2
3650.6	31	10.59_2
3665.6	Apr. 15	11.43_2
3679.6	29	11.94_2
3693.6	May 13	12.5

3425 *X Hydrae.*

(Continued from 350.)

Julian	Calendar	Mag.
	1896	
3604.6	Feb. 11	11.0
3628.6	Mar. 9	9.8

3425 *X Hydrae.*—Cont.

Julian	Calendar	Mag.
	1896	
3632.6	Mar. 13	9.68_2
3639.6	20	9.59_2
3647.6	27	9.64_2
3653.5	Apr. 3	9.39_2
3658.6	8	9.0P
3660.5	10	9.33_2
3665.6	15	9.10_2
"	15	9.2P
3672.6	22	9.77_4
3676.5	26	9.96_2
3679.5	29	9.56_2
3686.5	May 6	9.72_2

3477 *R Leonis minoris.*

(Continued from 350.)

Julian	Calendar	Mag.
	1896	
3577.5	Jan. 18	12.0
3601.5	Feb. 11	12.2
3627.5	Mar. 8	12.1
3633.5	14	12.4
3653.5	Apr. 3	11.8

3493 *R Leonis.*

(Continued from 350.)

Julian	Calendar	Mag.
	1895-6	
3540.7	Dec. 12	7.5r
3544.6	16	7.07_2
3544.7	16	6.6r
3559.6	31	6.61_2
3560.6	Jan. 1	6.57_2
3567.5	8	6.49_2
3570.6	11	6.5r
3573.6	14	6.08_2
3574.6	15	6.3r
3586.6	27	7.01_2
3597.6	Feb. 7	7.24_2
3612.6	22	7.44_2
3624.6	Mar. 5	7.8r
3627.6	8	8.0r
3632.6	13	8.2r
3633.6	14	8.2r
3636.5	17	8.2r
3658.6	Apr. 8	9.2r
3665.6	15	9.2r

3881 *V Hydrae.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3628.6	Mar. 9	8.52_2
3640.6	21	8.25_2
3646.5	27	8.28_2
3649.5	30	8.37_2
3660.5	Apr. 10	7.98_2
3665.6	15	8.2r
3666.6	16	8.21_2
3666.7	16	8.2r
3676.6	26	7.74_2
3687.5	May 7	7.74_2
3687.6	7	8.2r
3693.6	13	7.9r
3704.6	24	6.94_2

3890 *W Leonis.*

(Continued from 326.)

Julian	Calendar	Mag.
	1896	
3577	Jan. 18	11.5]
3597	Feb. 7	12.3]

3991 *S Leonis.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3604.6	Feb. 14	10.9
3636.5	Mar. 17	10.10_2
3640.6	21	10.39_2
3643.6	24	10.91_2
3652.6	Apr. 2	10.66_2
3658.6	8	11.40_2
3684.6	May 4	12.53_2

4315 *R Comae.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3740.6	June 29	12.6]
3752.6	July 11	11.9
3766.6	25	10.57
3771.6	30	9.83
3774.6	Aug. 2	9.25_2
3775.6	3	9.61_2
3776.6	4	9.28_3
3777.6	5	9.29_3
3778.5	6	9.31_5
3780.5	8	9.76_3
3782.5	10	9.81

4407 *R Corvi.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3640.6	Mar. 21	7.58_2
3646.6	27	7.30_2
3650.6	31	7.06_2
"	31	7.1r
3652.6	Apr. 2	7.1r
3653.6	3	7.1r
3655.6	5	7.1r
3658.6	8	7.1r
3660.5	10	6.63_2
3665.6	15	7.0r
3666.5	16	6.51_2
3666.7	16	7.1r
3672.6	22	7.02_2
3673.6	23	7.23_2
3676.6	26	6.72_2
3679.6	29	7.1r
3681.5	May 1	6.71_2
3687.6	7	7.1r
3689.6	9	6.95_2
3709.6	29	8.0r

4492 *Y Virginis.*

(Continued from 326.)

Julian	Calendar	Mag.
	1896	
3636.6	Mar. 17	12.1]
3653.5	Apr. 3	12.4]
3665.6	15	11.0]
3679.6	29	10.9
3680.6	30	11.01_2
3687.6	May 7	10.45_2
3689.6	9	10.41_2
3709.6	29	9.85_2
3712.6	June 1	9.99_2
3715.6	4	9.67_2
3721.6	10	9.85_2
3723.6	12	9.90_2
3731.6	20	10.12_2

4596 *U Virginis.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3636.6	Mar. 17 to	
3665.6	Apr. 15	11.6]
	5 dates	
3679.6	Apr. 29	10.1

4816 *V Virginis.*

(Continued from 326.)

Julian	Calendar	Mag.
	1896	
3679.6	Apr. 29	11.7
3687.6	May 7	11.26
"	7	11.2r
3693.6	13	11.2r
3709.6	29	9.86_2
"	29	9.7r
3713.6	June 2	9.4r
3715.6	4	9.71_2
3716.6	5	9.2r
3722.6	11	9.25_2
"	11	9.5r
3729.6	18	9.47_2
3731.6	20	9.54_2
3740.6	29	9.28_2
3742.6	July 1	9.04_2
3743.6	2	9.51_2
3746.6	5	9.03_2
3752.6	11	9.37_2
3758.6	17	9.82_2

4847 *S Virginis.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3658.6	Apr. 8	10.66_2
"	8	10.8r
3666.6	16	10.68_2
3666.7	Apr. 16	10.2r
3672.6	22	10.27_2
3687.6	May 7	9.46_2
"	7	9.0r
3693.6	13	7.6
3695.6	15	8.40_2
3699.6	19	7.34_2
3704.6	24	7.26_2
3707.6	27	7.07
"	27	7.5r
3709.6	29	7.4r
3711.6	31	7.09_2
3712.6	June 1	7.04_2
3713.6	2	7.44_2
"	2	7.4r
3715.6	4	7.38_2
3716.6	5	7.5r
3722.6	11	7.5r

4948 *R Can. Ven.*

Julian	Calendar	Mag.
	1896	
3743.6	July 2	8.8
3753.6	12	8.82_2
3755.6	14	8.80_2
3759.6	18	8.89_2
3762.6	21	8.74_2
3766.6	25	8.86_2
3774.6	Aug. 2	8.60_2
3777.5	5	8.99_2
3782.5	10	9.30_2

5070 *Z Virginis.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3655.6	Apr. 5	11.2]
3680.6	30	10.38_2
3684.6	May 4	10.05
3688.6	8	10.29_2
3693.6	13	10.22_2
3709.6	29	10.10_2
3713.6	June 2	10.50_2
3716.6	5	10.54_2
3721.6	10	10.33_2

5144 *Y Bootis.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3633.588	Mar. 14	
to .632		7.97_8
also .625		8.28
3651.547	Apr. 1	7.86_5
.561		7.85_5
.580		7.96_5
3680.526	Apr. 30	9.16
.530		8.22_3
.535		8.05
.542		8.68
.546		7.94_2
.550		8.37_2
.580		8.19_5
.631		7.98_3
3693.538	May 13	8.55
.540		8.61
.543		8.22
.545		8.05
.548		8.02
.560		7.95_5
.578		7.70_4
.620		8.04_5
.663		8.00_5
3706.559	May 26	8.14_5
.572		8.12_3
.582		8.08_5
.598		8.43_5
.618		7.95_5
3758.561	July 17	7.55_5
.584		7.72_5
.613		7.82_5
.637		8.20
.642		7.91_4
.655		7.78_5
.666		7.79_5
.678		7.77_5

5174 *RS Virginis.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3646.6	Mar. 27	9.71_2
3655.6	Apr. 5	9.85_2
3660.6	10	9.04_2
3666.5	16	10.10_2
3672.6	22	9.60_4
3673.6	23	9.35_2
3684.6	May 4	10.21_2

COMPARISON-STARS.

3264 *W Cancri.*

Star	DM.	Mag.	*n*
J	+25°2062	8.41	2
P	+25°2080	9.22	3*M*
Q	+24°2059	9.13	3*M*
R	+24°2070	9.25	5*M*
S	+25°2069	9.25	3*M*
X	+25°2060	9.31	3
Y	+25°2061	10.58	1
h	18*nf* *Y*	10.93	6
e	16*s* *Y*	11.49	5
i	5*nf* *Y*	12.11	2

3881 *V Hydrae.*

Star	DM.	Mag	*n*
A	−19°3125	5.25	0*M*
C	−19°3131	6.29	1*M*
D	−19°3122	6.71	2*M*
F	−19°3080	7.58	2*M*
H	−20°3272	8.09	24*M*
I	−20°3261	8.10	5
2*I*	−19°3131	7.17	1
K	−20°3280	8.24	26*M*
P	−20°3288	9.47	7
S	−20°3277	9.49	11

4847 *S Virginis.*

Star	DM.	Mag.	*n*
A	−5°3711	4.65	3*M*
C	−5°3706	6.15	10*M*
D	−6°3839	7.34	16*M*
1*D*	−5°3702	7.69	10*M*
1*H*	−5°3730	7.91	2
J	−7°3633	8.00	7
1*J*	−6°3843	8.25	5
K	−7°3635	8.89	7
M	−4°3527	9.06	2*M*
N	−6°3834	8.96	13

4847 *S Virginis.*—Cont.

Star	DM.	Mag.	*n*
P	−4°3506	9.46	3*M*
Q	−5°3735	8.66	3*M*
1*Q*	−6°3827	9.45	6
S	−5°3715	9.55	3*M*
1*S*	−6°3832	9.53	8
V	−6°3836	10.24	8
1*V*	−6°3840	9.72	4
d	4.4*n* 4.9*p* *V*	11.18	1
f	4.0*n* 2.9*p* *V*	11.58	1

MICROMETRICAL MEASURES OF THE STELLAR SYSTEM, F. 70 *OPHIUCHI*,

MADE AT THE LOWELL OBSERVATORY,

BY T. J. J. SEE.

The great interest attaching to the system of F. 70 *Ophiuchi* has induced me to measure it on the first available opportunity, notwithstanding the northern location of the object, thirty-two degrees from the border of the southern zone to which our double-star work is principally confined. Though I have examined the star on several evenings, under very high powers and with steady images, I have not found any certain trace of a third star. It will be seen that the anomaly in the motion of the system discussed in *A.J.* 363 remains very conspicuous. The position of the companion according to SCHUR's orbit (*A.N.*, 3220–21) is

t	θ_c	ρ_c
1896.61	294°.38	2″.36

By the mean measures given below it appears that the residual in angle has steadily increased, and now amounts to about *six degrees*. Our measures were made under the splendid definition of the new 24-inch Clark refractor, and the conditions were so favorable that I think the results can hardly be affected by any considerable errors.

Lowell Observatory, Flagstaff, Arizona, 1896 August.

t	θ_o	ρ_o	
	°	″	
1896.597	287.8	2.22	
1896.600	286.0	2.33	no trace of a third star
1896.602	288.8	2.38	
1896.605	288.1	2.16	round with 1000
1896.608	288.5	2.00	
1896.610	288.6	2.17	
1896.613	288.1	1.90	with new micrometer
1896.627	287.3	1.90	" " "
1896.608	288.0	2.14	8*n* See

My Assistant, Mr. W. A. COGSHALL, S.B., has secured the following observations:

t	θ_o	ρ_o	
	°	″	
1896.610	288.5	2.43	
1896.613	289.3	2.07	
1896.627	286.7	1.89	
1896.619	288.2	2.13	3*n* Cogshall

TWO NEW SOUTHERN VARIABLES,

BY ROBERT H. WEST.

These following stars are found in the list of suspected variables in the introduction to the Cordoba *Durchmusterung*, the data from which are given below for comparison with my observations.

C.DM. −34°4482.*

$\alpha = 8^h\ 7^m\ 53^s.4$; $\delta = -34°\ 45'.9$ (1875.0).

		M
Cordoba observations:	1890 April 18	9.0
	19	9.5
	1891 Jan. 6	10.0
	1892 May 29	8.25
		M
My observations are:	1896 Feb. 6	8.8
	March 5	8.5
	April 1	8.4
	April 16	8.2
	24	8.15
	May 6	8.5

The star is reddish.

C.DM. −24°12600.†

$\alpha = 16^h\ 4^m\ 25^s.8$; $\delta = -24°\ 34'.4$ (1875.0).

		M
Cordoba observations:	1887 May 13	9.0
	24	9.3
	1891 Sept. 3	invisible
		M
My observations:	1895 June 11	11.5
	Aug. 22	10.2
	1896 June 8	9.8
	Aug. 1	12

---

* 2933 *Y Puppis*; ED.

† 5796 *RX Scorpii*; ED.

Syrian Protestant College, Beirut, Syria, 1896 Aug. 4.

OBSERVATIONS OF COMET *d* 1896 (*GIACOBINI*),

MADE WITH THE 12-INCH TELESCOPE OF THE LICK OBSERVATORY,

BY WILLIAM J. HUSSEY.

1896 Mt. Hamilton M.T.	*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Sept. 5 8 13 13	1	14 , 8	+1 16.98	+2 39.0	17 13 5.02	−7 42 47.1	9.384	0.750
6 8 29 17	2	16 , 8	+0 34.81	+2 4.7	17 14 58.30	−7 52 26.4	9.438	0.785
7 8 26 3	3	8 , 8	−1 48.15	−2 35.5	17 16 51.24	−8 2 20.3	9.435	0.785

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	17 11 15.02	+3.02	−7 45 19.9	−6.2	Munich II, 6508
2	17 11 21.47	+3.02	−7 54 25.0	−6.1	½ (Munich I, 13806+Sj. 6181)
3	17 18 39.37	+3.02	−7 59 39.0	−5.8	Munich II, 6576

COMET *d* 1896.

This was discovered at Nice Sept 5 by Mr. Giacobini, and its position telegraphed from Kiel.

Sept. 1.3419 Greenw. M.T. $\alpha = 17^h 10^m 32^s$, $\delta = -7° 29'$

Observations have been received as follows, by telegraph, from the Lick Observatory:

Greenw. M.T.	α	δ	
	h m s	° ′ ″	
1896 Sept. 5.6804	17 13 5.0	−7 12 12	Hussey
6.6916	17 14 58.3	−7 52 26	"
7.6903	17 16 54.2	−8 2 20	"

From the U.S. Naval Observatory:

Greenw. M.T.	α	δ	
	h m s	° ′ ″	
1896 Sept. 8.5602	17 18 41.4	−8 10 9	Brown
9.5770	17 20 37.6	−8 20 36	"

Also, from the University of California, the following elements and ephemeris, computed by Messrs. Seares and Crawford from observations of Sept. 6, 7, 8:

$$T = 1896 \text{ Oct. } 10.34 \text{ Greenw. M.T.}$$

$$\left.\begin{aligned} \omega &= 154° 48' \\ \Omega &= 195\ 34 \\ i &= 9\ 6 \end{aligned}\right\} \text{M. Eq. } 1896.0$$

$$q = 1.1127$$

Ephemeris for Greenwich Midnight.

1896	α	δ	Br.
	h m s	° ′	
Sept. 12.5	17 27 16	− 8 52	1.31
16.5	17 37 16	− 9 36	
20.5	17 48 36	−10 21	
24.5	18 1 24	−11 7	1.65

COMET *e* 1896.

An announcement of this comet was forwarded by Mr. W. R. Brooks, and transmitted to the Editor by Mr. Ritchie of the *Science Observer*. It was round, faint, and diffused. Some days later Mr. Ritchie also communicated the fact that it had been first seen by Mr. Sperra at Randolph, Ohio, who had written Sept. 1 to Prof. Keeler of Allegheny Observatory, Pennsylvania, that he had found a nebulous object Aug. 31 which showed motion.

Mr. Ritchie has also sent observations, made at the Lick Observatory by Messrs. Hussey and Perrine, and forwarded by telegraph.

Greenw. M.T.	α	δ
	h m s	° ′ ″
Sept. 6.8355	13 51 11.1	+55 24 52
8.7176	14 1 51.6	+55 9 35
11.6956	14 25 39.1	+51 35 43

Mr. Sperra's observations were (probably in Washington time)

		α	δ
	h m	h m s	° ′
Aug. 31	9 14	13 8 25	+55 40
Sept. 1	—	13 14 30	+55 13

Elements and an ephemeris have been computed by Messrs. Seares and Crawford of the University of California from observations Sept. 6, 8 and 11, and forwarded by telegraph.

$$T = 1896 \text{ July } 10.61 \text{ Greenw. M.T.}$$

$$\begin{aligned} \omega &= 40° 39' \\ \Omega &= 151\ 2 \\ i &= 88\ 25 \\ q &= 1.1399 \end{aligned}$$

Ephemeris for Greenwich Midnight.

1896	α	δ	Br.
	h m s	° ′	
Sept. 14.5	14 49 0	+53 53	0.91
18.5	15 11 36	+52 37	
22.5	15 37 0	+51 3	
26.5	16 0 52	+49 15	0.76

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Published in Boston, tri-monthly, by B. A. Gould. Address, Cambridge, Mass. Price, $5.00 the Volume. Press of Thos. P. Nichols, Lynn, Mass.
Entered at the Post Office, at Boston, Mass., as second-class matter. *Closed Sept. 15.*

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